HEATING AND VENTILATING

A MONTHLY MAGAZINE FOR ENGINEERS AND CONTRACTORS CONCERNED WITH THE DESIGN AND APPLICATION OF AIR CONDITIONING, REFRIGERATION, PIPING, AIR SANITATION, HEATING AND VENTILATION IN BUILDINGS

Editorial Staff

Editor
CLIFFORD STROCK

Associate Editors
NATHAN N. WOLPERT
WILLIAM B. FOXHALL

Advertising Staff

Western Representative
GEORGE G. TURNER
228 North La Salle Street
Chicago 1, Ill.

Eastern Representative
HARRY J. TWINE
148 Lafayette Street
New York 13, N. Y.

Pacific Coast Representative
ROBERT H. DEIBLER
2506 W. 8th Street
Los Angeles 5, Calif.

Published by

THE INDUSTRIAL PRESS
148 Lafayette Street
New York 13, N. Y

President
ROBERT B. LUCHARS

Vice-President and Treasurer
EDGAR A. BECKER

Secretary and Publishing Manager
HAROLD L. GRAY

Subscription Rates

Yearly subscription in the United States and Canada, one year, $3; two years, $5; three years, $6; in all other countries, $5 per year. Single copies 30 cents. Entered as second class matter, April 18, 1925, at the Post Office, New York, N. Y., under the act of March 3, 1879.

CONTENTS FOR SEPTEMBER, 1948

VOLUME 45 NUMBER 9

FEATURE ARTICLES

Inaudible Sound—A New Tool for Air Cleaning 59
S. Young White

Does Oil and Gas Heating Demand Extra Radiator Surface? 65
A. G. Canar

The Heat Pump as a Hobby 81
C. F. Boester

How the Higher Courts Have Ruled 83
L. T. Parker

Heat Transfer Film Coefficient for Carbon Dioxide Vapor 88
B. F. Raber and F. W. Hutchinson

SHORT ARTICLES

Insulation for a Sidewalk 64

REFERENCE MATERIAL

Section—Design and Selection of Centrifugal Fans 67
F. P. Bleier

Data Sheet—Selection of V-Belt Drives 82

DEPARTMENTS

Washington News—*Loring F. Overman* 55
Picture Paragraphs 86
The Sales Engineer—*Bernard Lester* 91
Experience in my Classrcom—*T. W. Reynolds* 92
News of Equipment and Materials 94
News of the Month 102
Abstracts and Reviews 112
New Catalogs 114
Since the Last Issue 118
Getting Personal 126
Coming Events 128

Copyright, 1948, by The Industrial Press

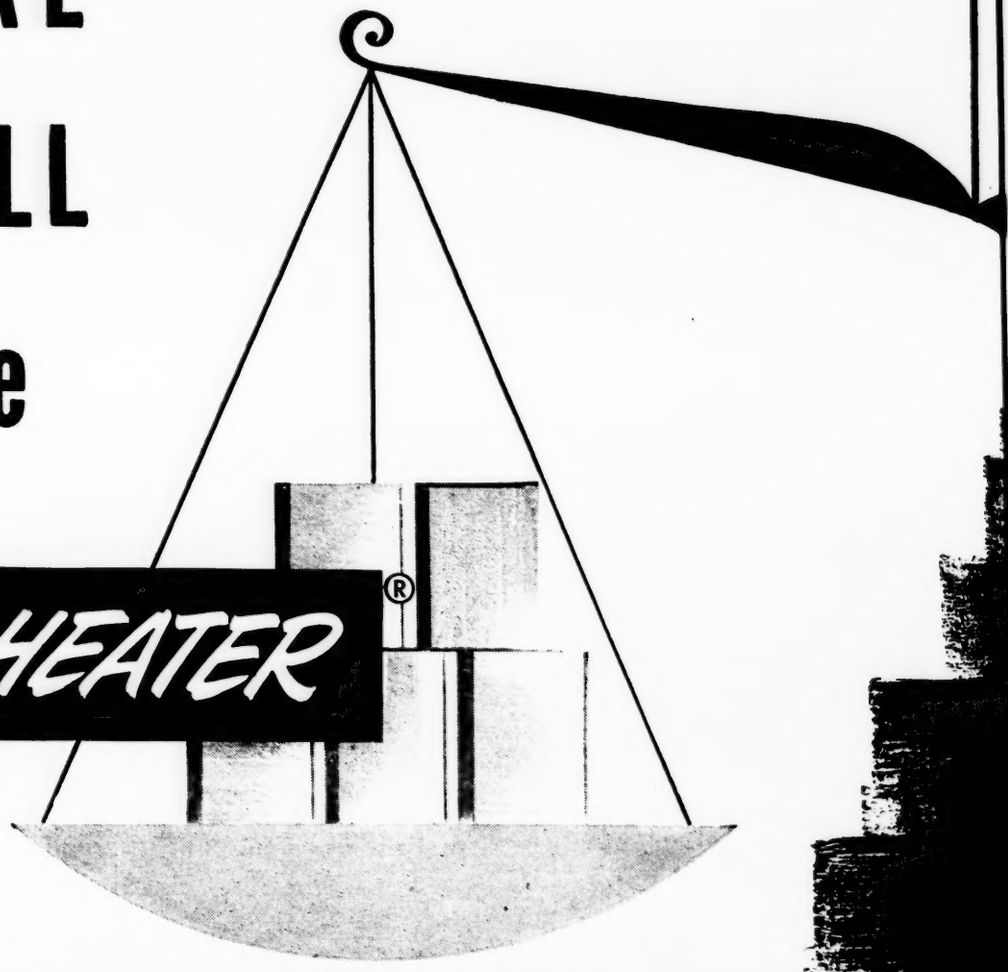
PUBLISHERS OF MACHINERY & MACHINERY'S HANDBOOK
The INDUSTRIAL PRESS

THIS MONTH'S COVER

General Blower Company centrifugal fans move air through the completely air conditioned laboratories and offices of Baxter Laboratories, Inc., Morton Grove, Ill., producers of blood plasma and administering equipment.

COMPARE THEM ALL with the

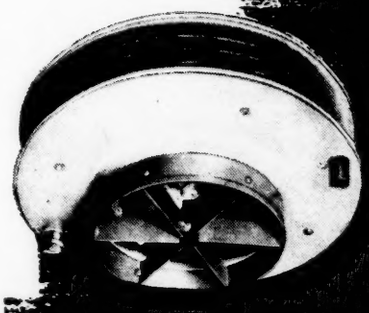
SPEEDHEATER®



ONLY THE SPEEDHEATER OFFERS ALL THESE 7 FEATURES

There's not a unit heater on the market that doesn't have some leading feature. But some features count for more. Far more—in the way of reliable, uninterrupted service. For instance, take the motor. In the case of the Speedheater it's a Westinghouse, backed by the Westinghouse motor-service plan. No matter where the heater is, or when trouble might occur, this plan won't let you down. But don't compare unit heaters on only one point. Westinghouse urges you to compare them *all* on *every* point. Ask your distributor or plumbing and heating contractor to show you the SPEEDHEATER. See for yourself how its seven main features add up to more dependability ALL THE WAY THROUGH.

Westinghouse Electric Corporation,
Sturtevant Division, 97 Readville Avenue,
Hyde Park, Boston 36, Massachusetts.



For High-Ceiling Applications

Washington News

LORING F. OVERMAN

WASHINGTON'S August was a multi-ringed circus, each act including one or more features of present or eventual interest to heating, ventilating and air conditioning industries. Among the headliners:

Congressional afterpiece.

Political barkering for Elephant and Donkey exhibits.

State Department wrestling with Russian Bear.

Inflation balloon ascent.

Draft machinery warm-up.

Red-spangled parade of spy suspects.

Washington midway of many marvels.

As August opened, Congress was making a hurried exit, after a short demonstration of tightrope walking. As expected, it responded none too well to the commands of the Presidential Ringmaster, and everyone concerned seemed content to have the bandmaster sound a final chord and send the performers back to political fence-building. During their short stay on the Washington stage, however, the legislators turned out a housing bill which cannot be overlooked by H&V readers, and a credit-control measure requiring larger down payments and speedier completion of contracts for things H&V readers design, produce and sell.

Although the housing bill was a disappointment to those who wanted government-financed public housing and greater stress on low cost homes, its provisions encourage the multiple-unit projects in which readers of this column are primarily interested. The housing bill, as signed by the President, will:

1. Permit the Federal Housing Administration to guarantee loans made to States, municipalities and non-profit corporations building rental housing.

2. Authorize FHA to insure an additional $800 million worth of mortgage loans on large-scale rental units where the cost for a family unit is not over $9,000.

3. Make it simpler for builders of prefabricated houses to get loans.

4. Speed building of housing projects by permitting builders to get 88% insured mortgage loans on projects of at least 25 homes costing $6,300 or less apiece.

5. Authorize Government insurance on 95% buyers' loans and 90% builders' loans on houses costing less than $6,300.

6. Permit Government loans on veterans' cooperatives, boosting the allowable cost from $1,350 per room to $8,100 per unit. There is an alternate ceiling of $1,800 per room.

7. Authorize 90% loans on non-veteran cooperatives.

8. Permit banks to sell to the Government as much as 50% of their GI and FHA insured mortgages acquired after April 30, 1948. The earlier limit was 25%.

In signing the housing bill, President Truman contended it deliberately neglects those most in need of adequate housing, since it makes no provision for slum clearance, low-rent public housing, or aids for farm housing.

GOP Barkers Reply

Spokesmen for the GOP-controlled Congress replied that the new housing bill will do about all that any housing bill could do in making living accommodations available. They contend that the labor supply, not easy financing, is the bottleneck in the housing program. To the complaint that little was done to lower building costs, they argue that if Government building contractors entered the already-tight labor market, construction wages would again spiral, driving present building costs even higher. The impression is left that low-cost housing, as understood in terms of prewar prices, is merely wishful thinking, and that by smoothing the path for those in the able-to-buy classes, their quarters will be vacated and become available for others not now in a position to purchase or rent new units.

"Divorced from sentimentality and from any desire to play on the feelings of ex-service people," observed one Republican spokesman, "it should be perfectly clear that with unemployment in the building trades virtually non-existent, housing output cannot be greatly increased. If there were half a million building mechanics idle, Federal housing might get some dwelling units built. The same cannot be said truthfully when the building industry is as fully occupied as it is now and has been for many months."

There may be some truth in the gentleman's approach, as well as in the assumption that the GOP—if it takes over the Administration in November—would like to keep Federal aid as an ace in the hole in the event of a deflationary trend. It has been observed in past deflationary periods that when a slow-down seriously affects the construction industry, the downward spiral is on. The next Administration, regardless of politics, may have need of a little pump priming late in 1949, unless all promises of reductions in Government spending are merely campaign chatter. Washington admits that anticipated postwar deflation schedules have been thrown completely out of kilter by Federal expenditures for ECA and rearmament. But it is beginning to wonder what new unexpected demand, if any, will keep the bubble up in the air for another year.

Wrestling the Bear

An answer—although it might not be a welcome solution—could come out of the Russia-Western powers conferences which had just gone into their second round as August ended. That it was necessary to extend the conferences beyond the expected

How to beat the rust problem —at LOW COST

There is more than one answer to the problem of corrosion in ductwork. But considering cost of materials and their workability, there is a practical solution in the use of a rust-defying, copper-bearing galvanized sheet steel like Beth-Cu-Loy.

Beth-Cu-Loy Sheets offer a double defense against rust. Beth-Cu-Loy is protected on the surface by Prime Western zinc applied in a tight, bright coating. Under the coating is the Beth-Cu-Loy base containing 0.20 to 0.30 percent copper, with 2 to 2½ times the rust-resistance of ordinary steel. Result: if rust eventually penetrates the zinc coating, it comes up against a barrier of copper-bearing steel.

Beth-Cu-Loy sheets have the easy-forming qualities that sheet-metal men like, yet they have adequate stiffness to permit the use of long sections in ductwork. They are simple to cut, to seam and to solder. With all of these advantages, Beth-Cu-Loy Galvanized Sheets cost very little more than ordinary zinc-coated steel sheets.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem Products are sold by Bethlehem Pacific Coast Steel Corporation

Beth-Cu-Loy Galvanized Sheets

BETHLEHEM STEEL

closing date was taken in Washington as a none-too-favorable sign, signaling lack of agreement and a probable continuation of pressures, the Berlin blockade, and other expensive musts.

Reflecting the wishes of the American people, Washington is confident that peace, even with some deflation, is far preferable to the alternative which could so easily come out of repeated encounters with the (to us) unpredictable tactics of the Bear.

Inflation Balloon

Thus, with peace as the goal in spite of provocative incidents, Washington is giving much thought to ways of slowing any further ascent of the inflation balloon. The action of Congress in renewing installment credit controls is a step in the direction of hanging on a bit of ballast, but neither political party really wants to go very far in an election year—with most voters happier over inflationary trends than they might be if the reverse were true.

Installment terms—a third down and 15 to 18 months to pay—were to become effective in September, but it was expected that credit controls through banks would be applied slowly and with considerable caution. Authority for banks to tigthten up on lending policies has been granted. The extent to which they will be applied will depend upon the balloon's tendency to gain or lose altitude without the application of behind-the-scenes stimuli. To date, moves in money control are minor ones, indicating a trend, but not of major importance in themselves.

Draft Machinery

With manpower the bottleneck in heating and ventilating industries and those they serve, probable effects of the draft are worthy to note. Expect a noticeable but gradual effect on manpower supplies as the armed forces draw an expected 560,000 men during the coming year. Initial draft, probably in November, may not call more than 15,000, but numbers will be stepped up monthly. Draft deferments for necessary men in industry may be difficult to arrange, for exemptions fixed by law and by Selective Service rulings leave little to the discretion of local draft boards.

Red-Spangled Parade

Overshadowing in interest most other happenings in Washington during August were the Congressional spy hearings. Outside of the world-wide ramifications these hearings imply, H&V readers may find them merely thought-starters.

For example, what is American business doing, or not doing, that makes "good American employees" turn to communism? How do they get that way? Don't they know they are many times better off under our system than under communism?

If employees do not know these American facts of life, it is probably because no one has taken the trouble to tell them. Yet someone from "the other side" has felt that each convert was valuable. American business, with incredulous surprise, is gradually awakening to the fact that its side of the story is not being told effectively. Through such organizations as the United States Chamber of Commerce and others, complete campaigns to tell the story of the American way of life have been made available to communities and to industry.

Revelations at the Washington spy hearings—whether or not they are finally adjudged "red herrings"—leave the impression that something is indeed "fishy." All American business, including units of the heating, ventilating and air conditioning industry, may find in the hearings a spur to greater activity in the field of employee contact.

Washington Midway

Along the Washington midway there were other things of direct interest to H&V readers.

In a press conference, for example, President Truman observed that the weather will determine whether there will be a sufficient supply of fuel oil, come winter. To work out a more scientific answer, 52 oil industry officials were appointed on August 23 to coordinate the distribution of gasoline and fuel oil in midwest and east coast states during coming months. Comprising two committees set up under a voluntary industry-wide program approved by the office of the Attorney General, the coordinating group was authorized to:

1. Give priority deliveries of both fuel oil and gasoline to the military.

2 Fill essential needs of farmers, railroads, institutions and other consumers whose services are necessary to the public health and safety.

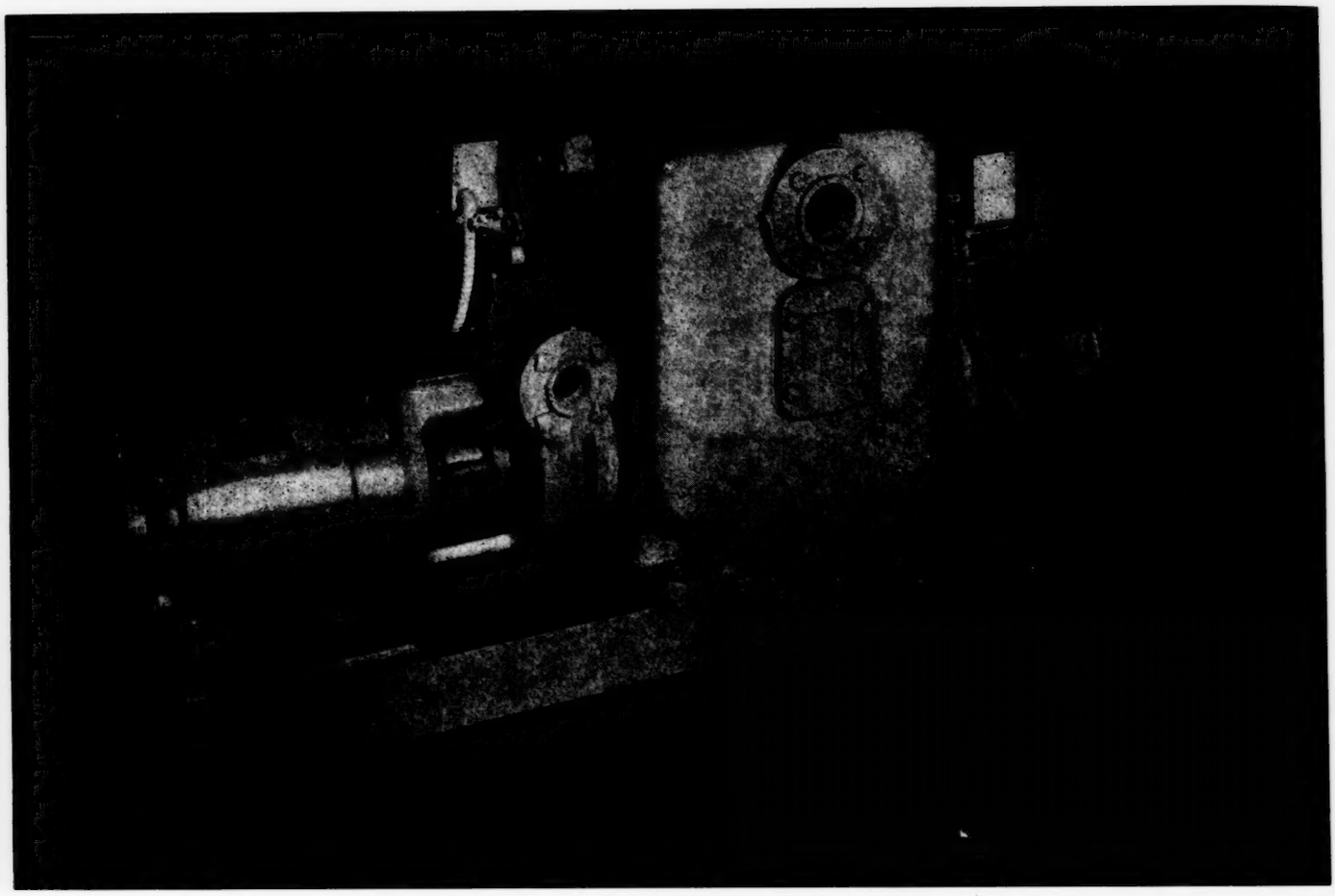
3. Assure that all other customers, including motorists and home owners, are equitably supplied.

Problems arising along the Atlantic seaboard will be handled by a committee headed by B. I. Graves, vice-president of the Tide Water Associated Oil Company, New York City. The midwest committee is headed by B. L. Majewski, vice-president of the Deep Rock Oil Corp., Chicago.

Although appointment of these committees lends credence to the conclusion of some alarmists that an oil shortage is inevitable, there are two favorable differences between conditions this year as compared with 1947. Production reached a peak of 5,507,050 barrels a day during the week of August 14, compared with 5,159,150 for the same week a year ago. Oil imports are exceeding exports by 150,000 to 200,000 barrels a day. Last year, exports exceeded imports by 25,000 barrels daily.

Export controls set up by the Commerce Department, with Congressional authority requested by the Interior Department, plugged the export leak. Through a quota and licensing system, oil exports were cut by one-third, while imports remained at the same level. Military demands, aggravated by the Berlin lift, have made inroads into reserves, but service requirements through January 1 are largely covered. Overall consumption for all U. S. uses is reportedly at a rate approximately 1,000,000 barrels a day higher than at the peak of the war, with military consumption 10 times as high as before the war.

MAXIMUM EFFICIENCY FOR STEAM HEATING SYSTEMS ON HEATING, DRYING AND PROCESS WORK.



JENNINGS CONDENSATION PUMPS

Designed for steam systems on heating, drying, or process work, these pumps offer the most reliable and efficient means of returning hot condensate to boiler or hot well. In many cases these pumps will save costly installation of boilers in a pit to provide gravity flow of returns from basement radiators and heating devices.

The Jennings Condensation Pumps are sturdy and compact in construction, and combine receiving tank, pump and driving motor in a single assembly. Pumps are bronze fitted throughout, with tobin bronze shaft. The pumping impeller is of special design, made possible by our wide experience with return line heating pumps, and is especially adapted for handling hot water with the greatest possible efficiency.

Full automatic control is furnished by means of a ball float and float switch mechanism mounted on the receiving tank. All wiring is made up at the factory, and it is necessary only to connect the pump to the system and hook up the leads. Complete information regarding these economical pumps sent promptly on request.

THE NASH ENGINEERING COMPANY

SOUTH NORWALK, CONNECTICUT, U. S. A.

INAUDIBLE SOUND

Ultrasonics or supersonics, the science of controlled high-frequency sound beyond the range of human hearing, is on the threshold of increasing application in the coagulation and precipitation of extremely fine gas- or liquid-borne particles, Mr. White believes. The economics of applications in heating, ventilating, and air conditioning, the author points out, will be in the hands of engineers in those fields. He attempts in this article merely to report on the current status of the art, to discuss the energies involved, and to present application examples and limitations sufficiently detailed to allow the reader to form a balanced judgement of the feasibility in each case.

ULTRASONIC energy is true sound energy beyond the range of human hearing. It was first recognized commercially by two British patents in 1912 which showed the use of ultrasonic energy to detect obstacles in the paths of ships. Applied at high intensity to any of the three states of matter, ultrasonic energy produces remarkable effects. As dramatically demonstrated by several experimenters, notably Alfred J. Loomis at Tuxedo Park, it can emulsify milk and mercury, disintegrate bacteria, determine the velocities, temperatures, and chemical constituents of moving gases, reduce solid masses to colloidal dust, or, conversely, coagulate suspended particles and precipitate them out of a liquid or gaseous medium.

Some of these effects have commercial implications, and the ability of ultrasonic energy to precipitate dust and mist from the atmosphere is the subject of this discussion.

What is Sound?

Classically defined, a sound wave is a compression wave followed by a rarefaction wave traveling longitudinally in an elastic medium. An audible series of such double waves, following one another continuously at regular intervals produces a tone. Since all the waves travel at uniform velocity in a uniform medium, they impinge on an object in their path (the ear) at intervals depending on the space between them. These intervals between sound waves determine two characteristics which are called pitch or frequency, and wave length.

The amplitude of vibration of a sound source determines the pressure difference between compression and rarefaction components of the sound wave. This pressure difference gives the engineer two more characteristics of sound, called amplitude (which determines loudness) and energy density.

What High-Frequency Means

If you sound the third *A* on your piano, you will hear 440 vibrations or wave cycles per second. One octave higher you will hear 880 cps, another octave 1760, and so on. The highest frequency an average 30-year-old man can hear is about 15,000 cps.

Ultrasonics, or, synonymously, supersonics, deals with an identical type of wave condition at frequencies above 20,000 cycles per second.

The upper limit of frequency has not been defined. Frequencies of 7 million cycles per second are easily obtained, and with a slight effort 30 million may be reached. The limit is probably where there is some discontinuity in the medium of the order of a wavelength. Since increasing the frequency shortens the wavelength, the upper limit of frequency is probably set by the mean free path of the molecules of gaseous medium. In a gas, this limit would be about 200 million cycles. In solids, the upper frequency is set by molecular size and is of the order of 1000 megacycles.

What Ultrasonics Can Do

Sonic waves can be reflected, focussed, refracted and so on in a manner similar to optical waves. But a sonic wave of 1,000 cycles is about a foot long in air and is difficult to handle with apparatus of reasonable size. Ultrasonic waves are less than an inch long, and may be as short as a thousandth of an inch or so. Such waves are quite practical to handle. Thus we have a tool for measurement of the properties of material, such as absorption, velocity and so on, which we can use in the laboratory, or for process control out on the line. So we may define ultrasonic energy from one point of view by saying it is a sonic wave so short that it readily can be used for testing various properties of a medium.

The second and by far most important future use of ultrasonics is for processing—that is, changing the nature of a load in some way. But in this use we find we must make an important addition to the definition. The papers already published show that important changes in a load are brought about by the combination of *high frequency* with *high energy density*. So we must define ultrasonics for processing as the use of ultrasonic waves of sufficiently high energy density to produce a marked effect in the material under treatment. There is always a certain minimum energy density that must be exceeded before any effect at all takes place.

In the simplest case, we can visualize an ultrasonic wave as a plane traveling in a direction perpendicular to its surface. The energy passing through a square inch of that plane in unit time is the energy density.

How Much Power

One distinguishing characteristic of ultrasonics used for processing is the fact that the energy density is several orders higher than that useful in sonic work. The radio loudspeaker is a common source of useful sound, and the largest home radio set with the volume wide open produces about one watt total energy in the air, which is a very loud sound indeed. Now if the cone of the speaker is about 12 in. in diameter, it would have roughly 100 sq in. of projected area, so the energy density of sound from the cone is about .01 watt per sq in.

In ultrasonic processing, we must have available many thousands of times this energy density to produce commercial effects. In fact, we shall seriously discuss generating this energy at over 50,000 watts per sq in.

How Sound Can Clear the Air

Our discussion concerns the precipitation of discrete particles, such as dust or fog, from air. These particles may be solid, liquid, or solid core with a surface film of liquid. Ultrasonics is effective down to the smallest particle sizes. The upper limit of size is about 10 or 20 microns, although 40-micron particles have been treated experimentally.

For our simplest case, let us consider a single droplet of water, two microns in diameter isolated in normal air. We shall set up a sonic wave of constant amplitude in this air and vary the frequency from zero to infinity. We shall look for three distinct zones of activity.

At very low frequencies, the droplet just washes back and forth with the wave motion. While the accelerating forces are low, the effective mass is also low so that the particle moves with only a slight lag to the wave.

However, at high amplitudes (energy densities) of these low frequencies, there are considerable pressure

Table 1—Ultrasonic Effects in Air, Water, and Steel

Medium	Frequency, Kilocycles	Power Density, Watts per sq in.	Pressure, Lb per sq in.	Amplitude, Micro-Inches	Acceleration	
					Miles, per sec per sec	G
Air at Zero Gage	25	6.5	± 0.4	1,830	620	107,000
Air at Zero Gage	25	6,500.	± 12.0	18,300	6,200	1,070,000
Air at Zero Gage	250	6.5	± 0.4	183	6,200	1,070,000
Air at Zero Gage	250	6,500.	± 12.0	1,830	62,000	10,700,000
Water	25	6.5	± 25	30	10.5	1,700
Water	250	6,500.	± 250	30	1,050.0	170,000
Steel	25	6.5	± 130	6	2.1	350
Steel	250	6,500.	± 1,300	6	210.0	35,000

changes effective on the particle, as will be realized by consulting Table 1. Sometimes coagulation occurs under these conditions.

Table 1 shows, for the three states of matter, the effect of frequency and power density on the pressure (positive and negative) developed by the sound wave, the excursion of the molecules of the medium with each wave, and the acceleration of the molecules.

As the frequency in our experimental chamber is increased to very high values, say several hundred thousand cycles, the picture reverses. The finite mass of the particle now keeps it anchored in space, and the gas washes back and forth past it. This heats the particle slightly, and a considerable change in electric potential occurs. Some coagulation can take place in this region of frequency also.

In the intermediate zone where the transition takes place, a region about an octave in band width, the particle has a pure random motion. This zone can be found for any condition and particle by Equation 1 (Calculations are usually worked out in cgs units and results converted to fps units).

$$\frac{X_p}{X_g} = \frac{1}{\left(\frac{4\pi d r^2 F}{9\,n}\right)^2 + 1} \qquad (1)$$

where

X_p = the excursion of the particle, microns
X_g = the excursion of the gas, microns
F = frequency of vibrations, cycles per second
π = 3.1416
d = density of particle, grams per cubic centimeter
r = radius of particle, microns
n = viscosity of gas, poises.

Assigning values for our 2-micron water particle, at 24,000 cycles, we have

$$\frac{X_p}{X_g} = \frac{1}{\left(\frac{4 \times 3.1 \times 1 \times (10^{-4})^2 \times 2.4 \times 10^4}{9 \times 1.88 \times 10^{-4}}\right)^2 + 1} = \frac{1}{2}$$

Thus the 2-micron particle partakes of one-half the gas motion at this frequency.

This calculation allows us to choose a frequency where the random motion of the particle is any reasonable fraction of the gas motion. Coagulation as it occurs in this region is fairly well understood, and is called orthokinetic coagulation.

The curve shown in Fig. 1 gives this half excursion value for a particle of specific gravity 1 in free air at 68F as a function of frequency. For very large particle sizes, above 10 microns, we are well down in the audible regions.

Orthokinetic coagulation occurs in two distinct steps. In an experimental chamber filled with air and a contaminant of uniform particle size, such as 2-micron water droplets, slowly increasing the intensity level of the 24 kc (24,000 cycles per second) wave

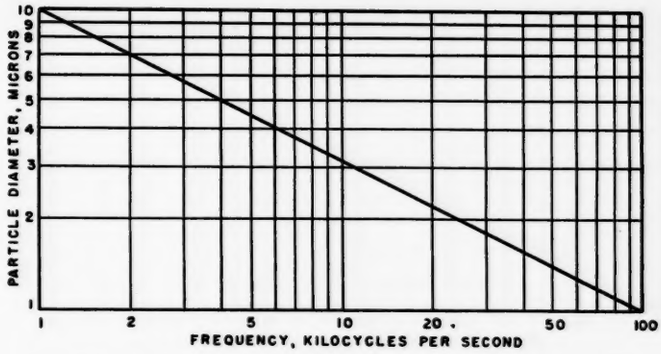


Fig. 1. Water particle diameters partaking of half gas motion at various frequencies.

results in collisions which produce aggregates of two, three and so on as the intensity increases. When aggregates of between eight and 13 particles are produced, the process reaches a critical point and in a micro-second or so aggregates of 200 to 256 particles suddenly form, apparently because positive and negative electric poles are generated on the smaller aggregates causing them to agglomerate. The first step is a collision step, while the second, due to electric charges, is a scavenging step.

How Far to Push

As already indicated, an important characteristic of the wave is its amplitude. If the particles are in a neat cubic lattice, with uniform spacing all around, first collisions will occur when each particle attains a random motion just sufficient to graze the orbit of the neighboring particles, which themselves are in random motion. The theory of probability, however, indicates our number of hits will be small unless either we apply the energy for an infinite time, which is impractical, or we increase the swing of the wave until the excursion of each particle is sufficient to overlap the orbits of the eight particles that form the corners of the cube of which it is the center. These eight will also be in random motion, of course.

Electrostatic repulsion between the particles due to their being similarly charged is quite great as their center distances become small, but Table 1 shows that the acceleration forces in the particles are also very large.

The amplitude of vibration of the molecules of gas, X_g in Equation 1, can be calculated from the formula,

$$X_g = \sqrt{\frac{\frac{2J}{dv}}{2\pi F}} \qquad (2)$$

Where

J = energy, ergs per second (1 watt = 10^7 ergs per second)
v = sonic velocity, centimeters per second. Other notation is as before

With the two equations given, the supersonic engineer can design for optimum frequency and power density for uniform particles in the range of .25 to 20 microns. And he can calculate acceleration of the gas molecules by the formula

$$b = 2\pi F \sqrt{\frac{2J}{dv}} \qquad (3)$$

Where b = acceleration, centimeters per second per second.

These formulas emphasize a unique feature of ultrasonic energy. The combination of high frequency and high energy density results in very high acceleration values which increase directly with frequency and as the square root of the power density.

It is notable that the 25-kc values in Table 1 are at almost the lowest frequency, and at only 1 watt per sq cm or 6.5 watts per sq in., which is about the lowest energy density where any commercial effect is to be expected. At four times the frequency, and with powers of 50,000 watts per sq in., the values become almost fantastic, but can be obtained.

In Table 1, we have chosen air of zero gage, water, and steel to be representative of the three states of matter. Notable are the low pressures, high accelerations, and large excursions of the molecules in a gas as compared to liquid or solid media.

How to Multiply Power

A practical engineer contemplating the energy density requirements is immediately struck by the enormous powers that seem to be necessary. The energy must be generated and paid for, whether the primary power source is steam, compressed air, or the 60-cycle line. There are two factors that reduce the apparent power requirement by a very large factor indeed. If either were lacking, ultrasonic treatment would be prohibitively expensive except for "jewelry" type loads. One is the time the power must be applied to the load, the other is the Q factor of the load. Let us investigate Q first.

Table 1 shows that at one watt per sq cm or 6.5 watts per sq in. we have set up a pressure wave in water of plus and minus 25 lb per sq in. These pressures, incidentally, are calculated by the formula, $P = \sqrt{2Jdv}$ where P is pressure in dynes.

Imagine a square inch column of water of infinite length suspended in a vacuum and excited by a 25-kc wave traveling along its length. As the wave travels, it loses energy, which loss shows up as a drop in sonic pressure. If we follow the wave until the pressure has dropped to half value, a convenient point of measurement, we find that this occurs at the rather astonishing distance of 40 miles. If we could weigh the water, we should find we have "treated" about 43 tons with 1 watt per sq cm at one end, and one-quarter watt at the other (halving the pressure reduces the wattage to a quarter). In practice, boundary reflection losses and wave cancellation effects would seriously reduce this efficiency, but the basic figure is very encouraging.

In practice, the processing chamber would have finite boundary layers separated by a few feet or so. If the walls of the chamber were perfectly reflecting the wave would travel until it hit the opposite wall and would reflect back undiminished by the reversal. When it returned to the starting point it would again reflect. Dimensions of the chamber can be arranged so that the power generator would give it a new push to reinforce the energy. Thus to the watt of real energy input can be added another reflected watt, less a very small amount of loss, so that almost two watts are available, and on the third time around almost three watts and so on. An enormous wattless component is built up by this resonance, which under ideal conditions would be thousands of times the actual energy applied. The amount of increase is the Q of the load.

Water must be contained in solid walls, say of steel, from which reflection is only about 85% under water. In many cases, design can recover some of this absorbed energy back from the walls. And if the chamber is 100 wavelengths long, this reflection loss occurs only at the end of each 100 cycles, so it is much less effective in weakening the build-up of wattless component than might be supposed.

The Q of air is much lower. At 25 kc the wave would travel only 187 ft to the half-pressure condition. However, reflection from steel or water in air is almost 100%, so the Q build-up in a chamber can be quite high in practice.

The Time Factor

The laws of resonant energy show that this process takes time, and roughly speaking, a Q of a thousand takes about a thousand cycles to build up to full amplitude. But at 25 kc, a thousand-cycle build-up period requires only a twenty-fifth of a second.

If we recall the ideal case set up with the square inch of water suspended in free space and forty miles long, we should obtain most effects such as coagulating clay, driving gas out of whatever we are interested in, in a thousand cycles of build-up and another thousand of full amplitude applied energy to complete the operation in a round figure time of a tenth second. Since we are treating 40 tons in a batch, so to speak, we can theoretically change batches ten times a second, for a total tonnage of about 400 tons per *second.* While this efficiency can never be realized, it is a true basic figure from which we deduct our inefficiencies, and it is a very promising base indeed.

Actual work on fog, titanium smoke, tobacco smoke and so on shows that about a watt of energy supplied will coagulate one cubic foot per minute. This does not mean a field strength of any particular amount, as there will always be a high resonance build-up in any chamber used.

This figure is probably not the ultimate. With higher field strengths than have been feasible with well known laboratory apparatus, the particle may be given a swing that will carry it well outside its lattice cube. Its collision with other particles increases as the cube of its excursion. But doubling the swing only squares the power required, so that there is an advantage of the difference between a cube and square. Some calculations show a potential of 5 cfm per watt input.

The power actually absorbed by the particles is in every case negligible. They are of very small mass in proportion to the mass of the gas, and in no case has any increased absorbtion of energy due to the presence of the particles been noted.

The percentage of clean-up is quite high, many people reporting about 99.9%. This is due to the far-reaching nature of the scavenging step of the process. In some cases it may be advantageous to inject addi-

tional contaminant to facilitate collision and obtain high efficiency clean-up.

Size of the Treating Chamber

It is evident that by taking full advantage of high *Q* and short treatment time, we are able to think in terms of very small treating chambers. Very often, the pipe or duct that carries the fluid flow is already large enough in cross-section for our purpose. In many cases the rate of flow in the duct will be too low for best design. Once we have coagulated our dust there is no purpose in further applying energy to air, for instance. In cases where higher velocity is required, a local pump or Venturi section may be set up.

The ease of handling ultrasonic energy allows us to confine it to a rather thin curtain in the duct of pipe. If our rate of flow were as high as 10 fps, and our time of treatment were a tenth second, this curtain would be a foot thick. To insure proper control of the field, some baffles and perhaps a special cross section piece could be inserted in the pipe or duct.

Particle Size Distribution

The picture so far has been simplified somewhat in two ways—first in assuming uniform particle size, and second, in assuming that the forces holding the particles separated are overcome only by violent collision. Actually, mixtures of particle sizes are easier to precipitate

In the case of two distinct sizes, say 5-micron and .5-micron, mixed in some ratio and exposed to a frequency of 24 kc, we know that the small particles will move almost 100% with the gas molecules, and the large particles will be anchored in space. While 24 kc can give no orthokinetic action to either of these sizes treated separately, still in the mixture we have a relative motion that performs the same function if the electric charges on the two sizes are suitable.

Another factor operating in favor of coagulating mixtures of particle sizes is the fact that ultrasonic generators give out energy in harmonics, as a rule, and each harmonic would take care of orthokinetic coagulation on a particular size particle. Since the effect covers about an octave, complete coverage of the spectrum could result.

Probable Uses

A useful feature of coagulation by ultrasonics is the ability of the operator to focus the energy in a beam, so that local small sources of aerosols can be effectively handled. For instance, in high speed packaging of cereal or any dusty product the rapid pouring funnel or injector is a potent source of dust. About 500 watts accurately directed at the spout should be effective.

A boiling kettle of some liquid could be locally treated. There would not be any effect at all on chemical fumes of molecular size, but if the kettle were giving off aerosol droplets, ultrasonics would be effective.

Probably an ideal load is the recovery of sulfuric acid mist, which often has a concentration of 5 grains per cubic foot over a tank, and a particle size ranging from two microns or so downward.

The smoke inlet into the base of a chimney is usually a round pipe of considerably less cross-section than the chamber at the base of the chimney. A thin curtain of ultrasonic energy across this pipe would be an effective precipitator.

The real test of the practicality of an ultrasonic installation is always a field test. It is very difficult to obtain meaningful data by setting up a test chamber in the laboratory. The data can be substantial only if gathered under actual service conditions. This means a trial installation, which is often not at all difficult. In many cases such a test could be run in an hour or so, and would only call for opening a hole in the side of some dust-carrying duct.

Even where calculations show discouraging potential results, a trial may show considerably more efficient action than pure theory would indicate. In general, the figures chosen for this discussion give the worst possible condition. Any modification of surface film, electric charge and so on always is favorable.

Power Generation

Ultrasonics has been extremely limited in its choice of power generators. Standard experimental setups have used three types—Piezo-electric transducers, magnetostriction, and the Hartmann whistle.

The Hartmann whistle employs the principle of an organ pipe assembly operated on compressed air of at least 13.6 lb gage, the critical pressure at which an orifice reaches sonic velocity in its discharge. Unfortunately, like most organ pipes, the efficiency is about 3½%. One designed for 40-lb operation, and taking the output of a .5-hp compressor of the paint spray type puts out about six watts at 25 kc, and, since the generator is a gas type, matches nicely into gas loads.

The Piezo-electric transducer depends on the fact that if certain crystals are cut in certain fashions, and an electric field is established through them, they will change dimensions. About 40 such crystals are known, including sugar. Two of commercial importance are quartz and Rochelle salt.

Quartz will change thickness one part in a million for a 7,000 volt per inch potential gradient. Its *Q* build-up is about 20,000 in air, and about three when loaded with oil or water. So for 100 watts output you must impress about 35,000 volts alternating voltage on the quartz, and this must occur under oil for insulation to prevent flashover.

The other crystals require less voltage, but give less absolute power. They are limited to a few millionths of an inch motion, and Table 1 shows that this represents little power in a gas but quite a bit in a liquid or solid.

The magnetostriction effect is that exhibited by a nickel rod. When magnetized, it changes length slightly. It also resonates at a critical frequency, and if in air builds up *Q* values of several thousand. A large diaphragm placed on the end will radiate energy into air, and most work on gas is done with this assembly. The power is very low—only several watts,

but by working in resonant glass tubes we obtain the standing wave pattern of sufficient amplitude to coagulate smoke. Efficiencies again run only 1% or so into gas, and about 3 or 4% in water.

While the three methods of generating power described are quite unusable commercially, they have allowed the exploration of ultrasonic energy in small powers.

High Power Generators

For gas loads the problem of producing unlimited power is at least on the verge of solution. It has been long recognized that a siren can be made of any power and of commercial efficiency if the frequency is sufficiently low to allow plenty of time to accelerate the gas to high velocity.

One siren in the literature develops about 2kw at the usual audio frequencies of 800 cycles or so, but at 30 kc falls to 50 watts, which gives a good idea of the problem.

A resonant jet turbo unit shown in Fig. 2 overcomes this difficulty by having resonant organ pipes ahead of the orifices. These resonant cavities build up large values of sonic pressure at the instant of opening of the orifice, so it has both the static pressure of the gas plus the instantaneous positive sonic pressure available to give high acceleration values at the proper phasing to give considerable output powers. It must be specifically designed for one frequency of operation, of course.

The performance of this unit promises to remove the power limitation which have prevented ultrasonics from "coming of age." The three and one-half inch rotor shown handles gas inputs of the order of 20kw and with apparent efficiencies of the order of 40%, which experience should improve considerably. It is the answer only to gas loads, of course.

Another high-power generator is a highly refined siren. In this unit air is forced out through holes at the rim of a disc and is cut by vanes in a stationary disc. The pulses of air are passed through acoustic horns which focus and direct the sound energy. It is said to operate at 50 to 70% efficiency but at the upper threshold of audibility which requires careful shielding.

The development of these units should allow serious thinking of commercializing very many of the effects

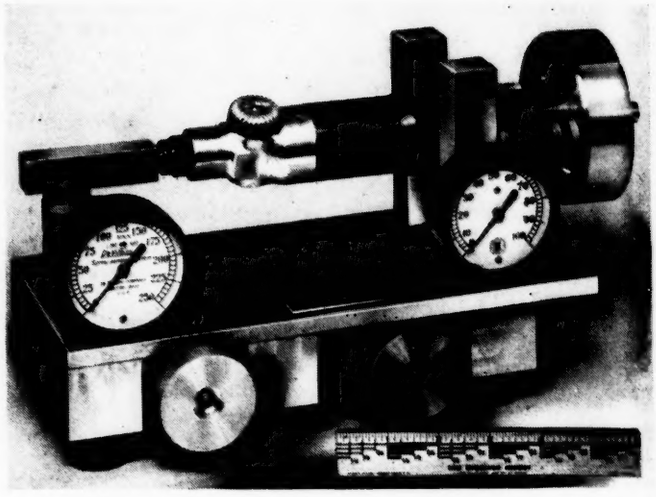


Fig. 2. High-power ultrasonic generator.

shown in the literature, plus the discovery of many more that were not discoverable because of the limited power density heretofore available.

Effect on Personnel

There are three regions of the sound spectrum that have different effects on the operators of sonic energy apparatus. The audible range from 1 kc to about 10 kc causes annoyance through the ear. A few milliwatts of energy released near the apparatus will over-excite the tuned response of the ear at that frequency, and cause severe annoyance. It is quite difficult to shield high power generators of sound in this frequency range.

The next region up the spectrum is between 10 and 18 kc, the upper threshold of audibility. A watt of energy in the room at this frequency level will cause the eardrums to be pushed in, and acute nausea to develop. The eardrums snap back into position a few hours later, and headaches may last for twelve hours. Again we must shield the generator, but since the frequency is fairly high much less absorptive material is required, so the problem is much easier.

At true ultrasonic levels, above 20 kc, the only effects apparent on humans are mechanical, such as heating of skin covered with hair. Since this requires great field strength a few watts escaping into the room are not serious, and since the frequency is so high an inch of rock wool will stop it completely.

Insulation for a Sidewalk

Cork insulation was used underneath a sidewalk installation to prevent the cold sidewalk from chilling the underground salesroom of S. S. Kresge Co., at Erie, Pa., which extended under the sidewalk.

A two-inch layer of corkboard was laid on temporary wood forms and a concrete ceiling slab was poured over the corkboard. Special galvanized nails were driven obliquely into each piece of corkboard to assure a good bond to the concrete. A waterproof membrane was poured above this concrete and then the paving.

After the concrete ceiling had set, the wood forms were removed and a suspended ceiling constructed about 18 in. below the surface of the corkboard.

This installation was specified to prevent the cold outdoor winter temperatures from reaching the warm moisture-laden air in the room as insurance that the moisture would not condense on the ceiling of the salesroom.

Does Oil and Gas Heating Demand Extra Radiator Surface?

ALFORD G. CANAR
Peoples Gas Light & Coke Co., Chicago, Ill.

Mr. Canar points up the variables involved in determining heat emission of a square foot of radiation and discusses the effect of changing from the steady heat of solid fuel to the intermittent heat of on-off firing with automatic gas and oil burners. A repeated build-up lag occurs which suggests 20-25% more radiation area to deliver the quality of heating expected with the new automatic devices.

HOW much radiator surface does any particular space to be heated actually require?

There are standard methods of figuring radiator capacity with which we are all familiar, some more crude or more refined than others. The method now in general use is based on a heat loss calculated for certain outside and inside design temperatures. Every feature of building construction is considered and a suitable heat conductivity factor applied. This method is as near true conditions of heat flow from a building as we can make it in the light of present knowledge.

Now we have a calculated heat loss more or less correct, depending on the care applied in the calculations. Then, if we are interested in steam radiation, we divide the heat loss by 240 and arrive at a certain figure for required radiation as so many square feet. One square foot of steam radiator surface is supposed to give off 240 Btu per hour. This unit emission depends upon what the steam temperature is and whether the steam is condensed at the exact rate of one quarter of a pound per square foot of radiation per hour. If the radiators condense more or less than the one quarter pound per square foot per hour rate, the heat applied to the surrounding space will be at a rate of more or less 240 Btu per hour. A space to be heated which at the start is at 40F will condense more steam in the radiators at any given steam pressure than a space at a higher temperature, and, as the heated space rises in temperature, the rate of steam condensation in the radiators becomes gradually less. Therefore, the radiation will emit 240 Btu per square foot per hour only part of the time, and a lower emission will occur the greater part of the heating period.

In the case of hot water radiation, the assumption is that the radiators will lower the temperature of the water in its passage through it by exactly 20F and, thereby, one square foot of radiation will give off 150 Btu per hour. This, of course, presupposes a certain rate of flow of the water. Any variation in the rate of flow of the water will alter the temperature differential between inlet and outlet of radiator. In addition, the temperature of the inlet water and the temperature of the air in the space to be heated affects the heat emission from the radiation. Hence, here again the rate of heat emission, which governed the choice of the amount of required radiation, is applied only part time and the bulk of the time, a lower heat emission is applied.

So it is evident that the amount of heat given off by any given radiator is considerable of a variable depending on many factors. In the case of a steam radiator, the heat output depends on steam pressure, rate of steam circulation into the radiator, rate of steam condensation inside radiator, average temperature of space to be heated, location of radiator in the heated space, efficiency of air venting, finish on radiator, design of radiator, and whether or not radiator covers are used and how these are designed.

In the case of a hot water radiator, it depends on the temperature of the entering water, temperature of exit water, rate of flow of water through radiator, whether or not the radiator contains some air, and various other factors mentioned above for a steam radiator.

In spite of all the various factors influencing the amount of heat given off by a radiator, the results are not generally bad, providing there is no appreciable shortage of radiator and the space to be heated is somewhere near the desired temperature. In other words, radiation installed according to the usual method of figuring will take care of a space reasonably well after the space is heated to approximately the desired temperature. However, in starting to heat a very cold room, considerable time will elapse before the room temperature is brought to the comfortable point.

Until recent years, practically all heating systems were fired with solid fuel and all our previous methods of figuring heating requirements were based on past experience when using solid fuel. With coal, the boiler is fired steadily, heat is being applied continuously, although at a variable rate over a day's period, and some heat is being delivered to the radiators practically all the time. In the case of a hot water boiler, no matter how low the fire is, some heat is being applied to the water, and boiler outlet water of around 110F will continue circulation as long as the return inlet water of the boiler is somewhat lower in temperature. So, with hot water, radiators seldom are as cold as room temperature because circulation rarely stops unless the fire goes out completely.

In recent years there has been a considerable transition from solid fuel firing to oil and gas firing, espe-

cially for residences and the smaller apartment buildings. This sort of firing brings in a big change—from steady to intermittent heat output. Now what happens to the radiators? They are intermittently hot and cold, giving off heat during firing periods and not doing so during the greater portion of the periods when the burners are shut off by the thermostat.

In a steam boiler, the water rapidly stops boiling, steam generation is stopped and the little steam in the system rapidly condenses, the radiators cool, and, in a very short time after the burner cuts off, there is no more heat being delivered to the rooms. With a hot water system, the radiators stay hotter for a longer time and cool more slowly because circulation of the heating medium continues for a longer period of time after the burner cuts off.

When the thermostat calls for heat later on, the burner may have been shut off for some time and the system may be comparatively cold. There is no steam or hot water circulating as soon as the thermostat turns on the burner; there is a delay till the water in a steam boiler is brought to boiling and enough pressure is generated to cause the steam to circulate through the cold piping to the radiators, and, in the case of a hot water system, water in the boiler must be heated until circulation starts and is accelerated by further heating. All this consumes time and a half hour or more may elapse before there is any definite response of heat at the radiators. During this heating-up period, the building temperature continues to drop until the radiators give off enough heat to offset the heat loss, after which the temperature starts to slowly rise again.

This brings up the point as to whether the amount of standing radiation as generally calculated, which worked out fairly well with steady solid fuel firing, is sufficient when intermittent firing is used, as with oil or gas. If the amount of radiation were greater, the building would be heated more rapidly. The radiators, assuming no change in burner input, would not become hotter any sooner, but the rate of heating from then on would be much more rapid. The off period would be shortened and the room temperatures would not drop so low, and, generally, there would be more comfort for the occupants. Another thing that is important—most important on any intermittent heating job—is that burner input be such that a steam boiler will rapidly steam and that build-up of hot water in a hot water boiler will also occur rapidly. Quick response from the boiler and rapid circulation to the radiators is the prime essential.

The proper burner input to achieve rapid heating is something which cannot be more than approximated beforehand. Rated input of a burner is a poor criterion to go by—experience has proven that. It is necessary to experiment with various inputs until the desirable input is achieved. For a steam boiler the input, from a comparatively cold start, should be such that one pound of steam pressure can be developed in at least twenty minutes. For a hot water boiler the water temperature, gauged by a thermometer at the top of the boiler, rises at an average rate of 1½ to 2F per minute. For the average residence, these heat build-ups are very satisfactory. For certain other buildings, faster heating may be more desirable.

The advantages of using radiation in excess of the usual calculated amounts for intermittent heating are: (1) shorter firing periods; (2) shorter off periods, both of which are on the economy side of the picture; (3) less room temperature variation; and (4) greater comfort for occupants of the building.

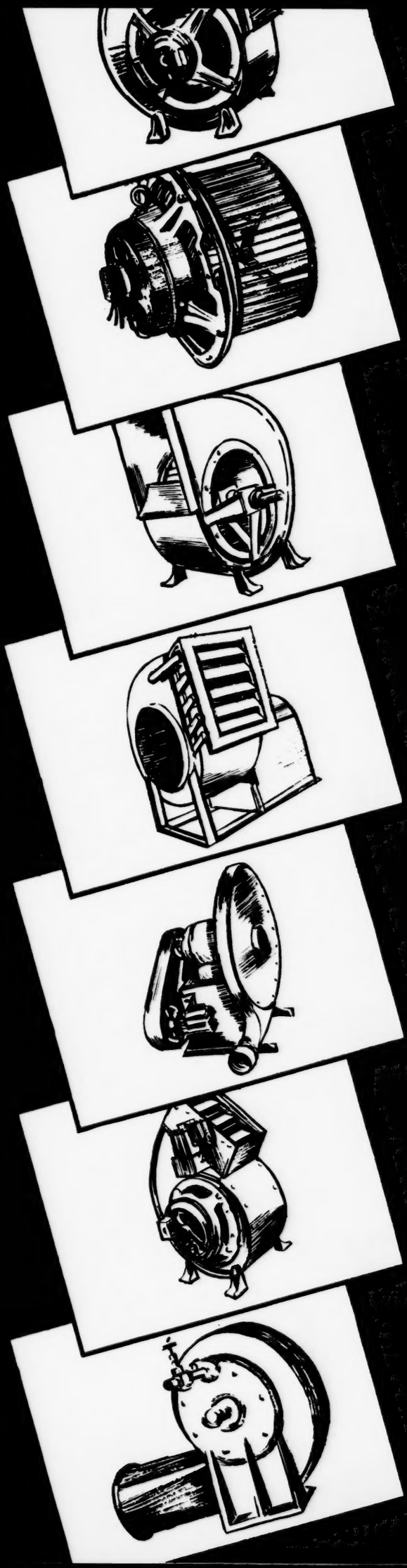
The disadvantages of using excess radiation are largely: (1) higher installation cost for larger boiler and more radiation; (2) possible temperature overshooting. Overshooting of room temperature can be considerably minimized by the use of a special thermostat which shuts off the burner prior to the set temperature which satisfies the thermostat, thus permitting the heat already stored in the system to build up the balance of the heat required. Overshooting of temperature is more prone with hot water systems than with steam.

Now that distinct advantages of excess radiation are to be expected, how much more radiation should be used in the average case over and above the calculated amount based on the heat loss? Since excess radiation tends to cause some overshooting of room temperature, it will be necessary that we exercise some care in the choice of a percentage of excess. Theoretically, the greater the excess of radiation, the more rapid the build-up of heat, but, no doubt, there is an economic limit involved beyond which the additional benefits are not enough to warrant increased installation cost. It appears that an excess of around 20 to 25% would provide sufficient additional advantages to offset higher original installation cost without making the installation cost too objectionable. The economy of operation over a daily period is evident since the burner on-periods will be shorter; hence, the total fuel consumption will be less due to the less time the burner operates. It may take some years of this economy to offset the increased installation cost, but the difference is made up with additional comfort, on which it is difficult to affix a monetary value.

The man who installs automatic heating, either with gas or oil, expects higher grade heating than he would expect to get from the use of solid fuel, and, with some excess radiation, he would get additional advantages of comfort and economy which he would not get without the excess of radiation.

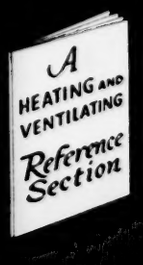
The most important feature of any home is comfort for the occupants and for six to eight months of the year, the heating system governs that comfort far more than anything else. Whatever can be done to increase the comfort of the occupants of a building should be done, even if it involves a little more initial cost. If a man is going to spend several thousands of dollars for a heating system, a matter of several hundred dollars more is not going to deter him if he can be assured of greater comfort plus some economy of operation.

So why not consider giving the new customer a better job if he intends to fire intermittently with gas or oil by giving him about 20 or 25% more radiation than he would ordinarily get and thus add to his comfort and ultimate satisfaction.



Design Performance and Selection of CENTRIFUGAL FANS

FRANK P. BLEIER
Consulting Engineer for Fan Design
Chicago, Ill.



Design, Performance and Selection of Centrifugal Fans

FRANK P. BLEIER

Consulting Engineer for Fan Design, Chicago, Ill.

According to their operating principles, fans are divided into two general classes; axial flow fans and centrifugal fans. An article on the three types of axial flow fans appeared as Heating and Ventilating's Reference Section of October, 1946. It will be the object of this present article to describe the different types of centrifugal fans and their fundamental principles of operation; to discuss various design features and their effects upon performance; and to give examples of practical applications.

AN analysis of what goes on inside any fan unit is necessarily based on aerodynamics. Air enters the unit at the inlet and leaves at the outlet, and in between it acts upon certain stationary and moving parts; it is the interaction between these parts and the air stream that must be studied, so that rules and formulas may be found which will relate the shapes of these parts to the resulting performance of the unit and thereby open the door to mathematical fan design.

Armed with this mathematical key, the designer of a new fan will simply apply his rules and formulas to a specific case and thereby determine the shape of the various parts in such a way that air is moved at a specified rate (cfm) against a specified resistance (static pressure) and so that a number of additional requirements regarding space and service are fulfilled. For peak efficiency with quiet operation, the unit should be designed so that the interaction of air and parts take place with a minimum of turbulence and shock. Air velocities should be parallel to adjacent surfaces, velocity changes should be gradual, and projections into the air stream should be eliminated, or at least streamlined, as far as possible.

In our search for a mathematical approach to design, we find a startling difference in availability of data between the axial flow fan and the centrifugal fan. For the axial flow fan, a complete set of formulas has been derived on a theoretical basis expressing optimum dimensions as functions of the specifications to be met. These formulas can be applied to any type of axial flow fan without the additional help of experimentation or of empirical factors, and they will usually result in a commercially practical unit. For the centrifugal fan, however, no such comprehensive theory exists for commercial application. While a set of formulas is available, only in very rare cases will it lend itself to the design of a commercially practical unit. In the majority of cases, the resulting unit would be of monstrous dimensions, not suitable for practical installations. Empirical factors, derived from previous experimentation, have to be used at various stages of the design calculation, and these factors are not constant but vary with the type of fan.

This does not mean that aerodynamic considerations are completely ignored in the design of centrifugal fans. The aim is still to obtain smooth flow conditions, but this aim can be attained only within certain empirically deduced limits for commercial types of centrifugal fans. This situation has apparently been a great disappointment to many a fan designer. There are in existance some theoretical publications on centrifugal fans, ingenious in approach and interesting to read, but disregarding the fact that the theory as presented is applicable only in very rare cases.

Operating Principle

Fig. 1 and 2 show the general shape of a typical centrifugal fan. The fan wheel, Fig. 1, consists of a hub center, a back plate, a number of blades, and a retaining ring. The fan casing, Fig. 2, normally consists of two side plates, a scroll, and several additional parts, such as the inlet cone, the cut-off, and the supports for the housing and for the drive arrangement.

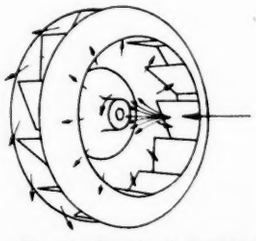


Fig. 1. Typical centrifugal fan wheel with blades inclined backward.

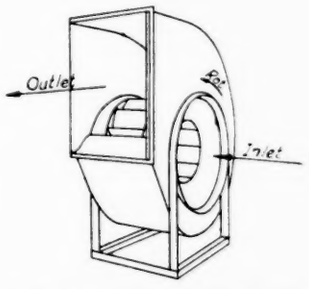


Fig. 2. Typical centrifugal fan unit showing inlet and outlet side.

As the term *centrifugal* indicates, the air flow here is caused mainly by centrifugal force. As the fan wheel rotates, the rotating air between the blades is, of course, subject to centrifugal force which causes it to flow outward, or which, at least, is the main cause for its flowing outward. Simple displacement of the air core at the hub by shearing action of the blades, also contributes to the effect, but to a lesser degree.

Naturally, the air flowing outward through the blade channels has to be replaced from somewhere, otherwise an ever increasing vacuum would be created in the central portion of the fan wheel. This means that air will be sucked into the central low-pressure space

Fig. 3. Blade arrangements for centrifugal fan wheels. (A) Backward-inclined with backward curvature; (B) backward-inclined, straight; (C) backward-inclined, forward curvature; (D) backward-inclined, double curvature; (E) radial-tip, inlet curvature; (F) straight radial; (G) forward-inclined.

through its open face, forming a funnel-shaped air stream (see Fig. 1) which turns 90 degrees radially and flows outward through the blade channels. The individual air streams leaving the blades usually are collected and reunited in a single air stream by means of a scroll casing, as shown in Fig. 2.

Types of Fans

According to their blade shapes, centrifugal fans are divided into three groups which are designated as having

(a) backward-inclined blades
(b) radial-tip blades
(c) forward-inclined blades.

Variations of these groups are shown in Fig. 3. A blade is called backward-inclined if the angle between its slope at the outer tip and the trailing segment of a tangent to the circumference of the wheel at that point, i.e. the blade angle at the tip (see β_2 in Fig. 6), is smaller than 90°; it is called radially ending if that blade angle is equal to 90°, and forwardly inclined if that blade angle is larger than 90°. While the outlet blade angle, β_2, can be smaller than, equal to, or larger than 90°, the inlet blade angle, β_1, is near the tip, are also in use.

The schematic sketches of Fig. 3 show four shapes of backwardly inclined blades. The usual shape has a slight backward curvature, as shown in Fig. 3A, but often the blades are straight, as in Fig. 3B, and—going one step further—occasionally they even have a slight forward curvature, as in Fig. 3C. Special blade shapes, such as that in Fig. 3D, having a forward curvature near the inlet and a backward curvature near the tip, are also in use.

Fig. 3 also shows two shapes of radially ending blades. The usual shape, as shown in Fig. 3E, is similar to that shown in Fig. 3C, and, again obtained by going one step further, it starts with an inlet angle β_1 smaller than 90° and uses a slight forward curvature to attain a 90° tip angle. This blade shape is frequently used in mechanical draft fans and in pressure blowers. Fig. 3F shows a simplified shape which eliminates the inlet curvature and is straight and radial all the way through. It is less expensive in production (and therefore frequently used), but also less efficient in performance. Its main application is in simple steel plate fans, pressure blowers and turbo blowers.

Fig. 3G shows the shape of a forwardly inclined blade. It is similar to that shown in Fig. 3E and again is obtained by going one step further. It starts with an inlet angle β_1 smaller than 90° and uses a strong curvature to attain a tip angle β_2 larger than 90°. Notice that the blade shapes in Fig. 3 form a continuous series with steadily increasing outlet blade angles. Each of these various blade shapes has its advantages and disadvantages and accordingly each is well suited for certain applications for which the others may not do.

To anticipate somewhat: If fan wheels of the same diameter and speed, but having these different blade shapes, are compared, the alphabetical sequence in Fig. 3 also follows a parallel design trend toward increasing inlet diameter, axial width, number of blades, capacity, static pressure, aerodynamical load, turbulence and noise level and of decreasing efficiency and stability of performance. While there may be occasional deviations from this general trend (for instance, pressure blowers with radial-tip blades often have a very small inlet diameter), the above sequence will in most cases be a good guide.

In addition to blade shape, there are several other design characteristics according to which centrifugal fans are sometimes classified, such as drive arrangement, direction of rotation, type of inlet and type of discharge. For instance, the unit shown in Fig. 2 has direct motor drive (not visible), clockwise rotation, single inlet and top horizontal discharge.

Drive arrangement. In the majority of cases, fan wheels are driven by electric motors because of the high efficiency and smooth operation of such motors. Other drives, such as engine drive or turbine drive, are occasionally used, especially in places where electric power is not available. Fig. 4 shows a turbine-driven blower. The fan wheel can be mounted directly on the motor shaft or the power can be transmitted by rigid coupling, flexible coupling or belt drive. Eight possible drive arrangements have been adopted as standard by the National Association of Fan Manufacturers (see NAFM Bulletin X-12, Table 5). The decision on the drive arrangement to be used in a specific instance depends on (a) the running speed of the unit and (b) the type of installation. Direct drive, as shown in Fig. 5, is by far the cleanest construction and is used wherever possible, but in many applications belt drive is indicated.

Belt drive has two advantages over direct drive:

(1) Greater flexibility (any running speed can be obtained)
(2) Lower first cost in cases of low-speed units, since high-speed electric motors can be used instead of expensive low-speed motors.

Direct drive, on the other hand, has two advantages over belt drive:

(1) Lower power consumption, as belt and other losses are eliminated
(2) Lower installation and maintenance cost.

For these reasons, direct drive is prevalent in small sizes (high running speeds), belt drive in large sizes (low running speeds).

The direction of rotation can be clockwise or coun-

ter-clockwise and is usually determined by viewing the unit from the drive side.

Type of Inlet. The constructions shown in Fig. 1 and 2 are of the single-width, single-inlet type. By combining a clockwise and a counter-clockwise fan into one unit, a double-width, double-inlet fan is obtained, delivering about double the capacity against the same static pressure, while consuming about double the brake horsepower. This construction is a practical and inexpensive solution for many applications where the volume requirements would otherwise be too large for the size and speed of the unit. For exhaust installations, the fan inlet is sometimes equipped with inlet boxes, which are furnished as part of the fan casing, especially with double-width, double-inlet fans. The inlet boxes connect the duct work with the inlet openings of the fan and are usually of simple rectangular shape.

Type of Discharge. In most centrifugal fans, a scroll casing is provided, as shown in Fig. 2, 4, and 5. Its main function is to collect the individual air streams from the blades and to reunite them into the single air stream discharging through the outlet opening. Obviously the location and direction of the discharging air stream relative to the inlet air stream may vary according to demands of the installation. Sixteen different discharge arrangements have thus been adopted as standard by the NAFM (see Bulletin X-12, Table 6). Additional in-between positions are also used occasionally. Most fan units are designed in such a manner that the manufacturers can furnish them for any discharge arrangement required to suit the customer's need. Some designs, especially of smaller units, are for universal discharge, meaning that even after complete assembly the discharge arrangements can still be changed by simply removing a few bolts and moving the supporting legs to a different position.

A different type of discharge sometimes is used for applications in which air is to be delivered into a large space. In such cases, the scroll casing can be completely eliminated and the individual air streams, leaving the blade channels, simply diffuse outward into the space. This arrangement is sometimes called radial discharge or circumferential discharge; the latter term really comes closer to the truth in view of the direction of the discharge velocity (c_2 in Fig. 6) and is also descriptive with respect to the spot where the discharge takes place. This type of discharge, if correctly applied, can be very advantageous: simple in construction and excellent in performance; it will be further discussed in a later section.

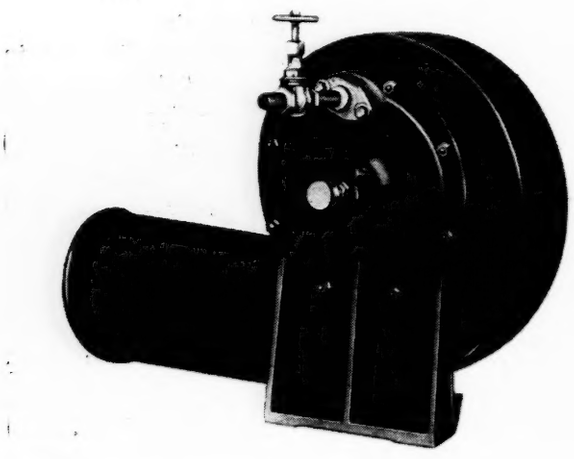


Fig. 4. Centrifugal fan driven by a built-in, compressed-air turbine. (Coppus Engineering Corp.)

Design of Centrifugal Fans

The procedure of designing a new fan always starts with an analysis of the specifications. In general, the air volume (cfm) and the static pressure (in. w.g.) are specified (sometimes requiring conversion to standard air conditions) and the first characteristics determined are the type of blade, the wheel diameter, and the running speed. This problem by no means has but one solution. Quite frequently, for instance, the specified duty can be met either by backward blades at high running speed or by forward blades at low running speed; the decision will then depend on additional requirements such as space limitations, efficiency, noise level, range fluctuations, first cost, operating cost, details of the installation, etc., which may point to a certain blade shape.

Once the type of blade has been decided upon and the corresponding wheel diameter and running speed have been determined, we can proceed with the design of the various parts of the fan unit.

Centrifugal Fan with Backward Blades

Let us assume that the specifications for air volume, static pressure, efficiency, noise level, etc., led to the selection of a fan wheel with backward blades having an outside diameter d_2 and running at a speed of n rpm. Such a wheel is shown schematically in Fig. 6, which also includes the velocity diagrams for the inlet and outlet, an explanation of the customary symbols and an analysis of the blade channel.

Inlet diameter. The air stream enters at the axial inlet velocity V_1 over the inlet area, which is a circle of the diameter d_1. This inlet velocity should be kept as low as possible so that inlet losses will be low, hence the inlet diameter should be as large as possible. This would, however, reduce the annular space left for the blades and thereby reduce the static pressure produced. A compromise must, therefore, be made. Several empirical formulas are available, setting the inlet diameter proportional to the cube root of the air volume, as could be expected. For backward-blade fans, the diameter ratio d_1/d_2 usually is between 0.60 and 0.75; the larger values obviously will be used in designs for relatively large volumes, i.e. in designs in which the volume is large for the size and speed of the fan; in designs for very low volume (such as pressure blowers), values lower than those mentioned are used: there the diameter ratio varies between 0.2 and 0.5.

The shape of the stationary inlet is usually that of a cone. For optimum flow conditions, a venturi-shaped inlet is sometimes used, especially in designs having a relatively high inlet velocity. Of great importance is the inlet clearance, i.e. the gap between the station-

Fig. 5. Typical, direct-connected, centrifugal fan with partially recessed motor. (Ilg Electric Ventilating Co.)

ary inlet and the rotating retaining ring of the fan wheel. This gap between two circular edges of about the same diameter d_1 has to be kept small to avoid excessive back leakage of the air stream as this would result in a drop of volume, pressure and efficiency. For a 30-in. wheel diameter the inlet clearance should be not more than $\frac{1}{8}$ in. Quite often the retaining ring (which, for backward blades, usually is of conical shape) is extended into a narrow cylindrical lip which overlaps the edge of the inlet cone, so that the air leakage is reduced. In extreme high-pressure applications beyond the range of normal ventilation requirements, such as in multi-stage turbo blowers, the simple overlapping may not be sufficient and labyrinth seals may have to be used.

Inlet width. The first thought will be to make the inlet width, b_1 in Fig. 6, as large as possible so that the air velocity c_1 and the corresponding losses will be kept low. On the other hand, the inlet flow conditions are largely dependent on the ratio b_1/d_1. The smaller this ratio is, the better are the inlet flow conditions. A compromise must therefore be made, as was done in the case of the inlet diameter.

For low-volume high-pressure wheels, the following reasoning is employed: The entering air stream is funnel-shaped as shown in Fig. 1, and must make right-angle turns before entering the blade channels. Such right-angle turns, however, are a ticklish proposition, as is known from simple elbows in ducts. The air stream is likely to follow its inertia and to shoot across the blade width; in other words, instead of evenly filling the blade channel, it might separate from the retaining ring and crowd toward the back plate. Obviously, such an uneven condition would be harmful to the performance; it can be corrected somewhat by a smooth curve provided at the inlet edge of the retaining ring, but the most effective method against it is an acceleration of the inlet flow during the right-angle turn. This means that the area of passage should be smaller after the turn or, expressed in mathematical symbols, that the ratio b_1/d_1 should be smaller than 0.25.

The requirement that b_1 should be smaller than 0.25 d_1 leads to narrow wheels that may be efficient, but are able to handle only small air volumes. For large-volume wheels, the width b_1 has to be increased beyond this limit. The increase in air volume thus obtained, however, is (a) smaller than in proportion with the increase in width, and (b) at a sacrifice of flow conditions and sometimes of efficiency.

The further the width is increased, the smaller is the resulting gain in air volume, because the constant inlet diameter acts as a throttle if the inlet velocity becomes too great. Finally a point is reached where a further increase would not seem worth while any more, considering the structural difficulties caused by an overly wide wheel. In general practice, $b_1/d_1 = 0.4$ is a good average value and $b_1/d_1 = 0.55$ is considered the upper limit.

The sacrifice in flow conditions is sometimes made up by a decrease in the blade angle, resulting in a reduction of the air velocities and of the corresponding losses. The original good efficiency may thereby be restored, but at the same time the air volume has again been somewhat reduced so that the width increase has become even less effective.

Summarizing, it may be said: Narrow wheels have the advantage of being more compact, i.e. they deliver greater volume per inch of axial width. Wide wheels have the advantage that the total volume delivered is larger. Flow conditions are smoother in narrow wheels, but air velocities are lower in wide wheels. Resulting efficiencies can, therefore, be comparable.

Velocity Diagrams and Blade Angles

Inlet. Now that the inlet diameter d_1 and the inlet width b_1 have been determined, the blade velocity u_1 and the absolute air velocity c_1 (again with reference to Fig. 6) can easily be calculated and the velocity diagram, as shown in Fig. 6, can be drawn. The absolute air velocity which normally is in radial direction (no inlet spin), is the vector sum of the circumferential blade velocity and the air velocity relative to the blade w_1. The values for w_1 and for the inlet air angle β_1 are then simply determined from the triangle. The inlet blade angle is made either equal to β_1 (tangential condition) or slightly larger (angle of attack for diversion of the air stream).

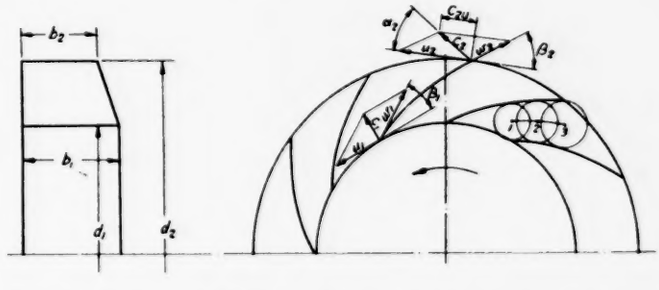


Fig. 6. Backward-blade wheel showing velocity diagrams at inlet and outlet and an analysis of the blade channel.

Outlet. The velocity diagram for the outlet, as also shown in Fig. 6, follows a similar procedure, but it can be drawn only after two yet unknown variables have been determined: the circumferential component c_{2u} of the absolute air velocity and the blade width b_2. The circumferential component is the circumferential motion imparted to the air by the rotating blades. The determination of these two variables is discussed in succeeding paragraphs.

As an indication of the general trend, it may be said that an increase of the inlet blade angle or of the outlet blade angle generally results in an increase of the volume or of the static pressure, respectively, as long as these blade angle increases are within limits. If they are overdone, no increase of the ratings will be effected, for several reasons such as: The angle of attack and the corresponding shock may become so large that separation of the air flow is caused; the blade channel may become so wide and short that the air flow is no longer sufficiently guided (in this case, a simultaneous increase of the number of blades may correct the condition).

Circulatory flow. As indicated by the vectors w_1 and w_2 in Fig. 6, the blade channel is more or less evenly filled by a relative air stream which is essentially parallel to the channel. As the blade channel rotates around the axis, a peculiar phenomenon, called circulatory flow, takes place. The air particles occupying the space between the blades do not quite keep up with the rotation of the channel walls, but—because of their inertia—lag behind. Relative to the channel, they therefore rotate slowly in the opposite direction. This relative vortex, called circulatory flow, which is superimposed upon the main relative flow, is comparatively small, yet large enough to notably reduce the pressure produced.

What practical effect, if any, does circulatory flow have upon design procedure? The circumferential component c_{2u} is the one responsible for the pressure produced. If there were no circulatory flow, it could be calculated from Euler's well known turbine equation, which presents c_{2u} as a function of the specified pressure. Under actual conditions, however, a correction factor has to be applied to compensate for the pressure drop due to circulatory flow. This correction factor tends to increase c_{2u} and thereby the blade outlet angle β_2.

The determination of this correction factor is very difficult. The shape, width and number of blades will influence it and the poorer the guidance of the air is while passing through the channel, the stronger will be the circulatory flow and the larger will have to be the effected increase of c_{2u}. Several formulas have been set up (by Stodola and others), but they are approximations rather than accurate values. In many cases, empirical data derived from previous experimentation have to be used.

Number of blades. The number of blades is, again, the result of a compromise between two conflicting requirements. On the one hand, the channel should be narrow enough for good guidance of the air stream, on the other hand, it should be wide enough so that resistance to air flow is not too great. For these reasons, the number of blades, usually between eight and 20, will be largest in designs having large diameter ratios d_1/d_2 and large inlet blade angles β_1.

Partial blades, placed between the main blades, but only in the outer portion of the annular space, have the function of reducing the channel width where it is largest. Occasionally they may slightly improve the performance, but in most cases the gain does not justify the structural complication.

Blade channel. This is the final step to complete the design of the fan wheel. A blade width b_2 for the wheel outlet is tentatively assumed (usually somewhat smaller than b_1) and the corresponding outlet velocity diagram is drawn. The resulting blade outlet angle β_2 is compared with β_{2s}, the value which would be obtained if the blade were straight; Fig. 7 gives a graphical presentation of β_{2s} as a function of β_1 and of d_1/d_2. If a backward curvature is desired, β_2 has to be smaller than β_{2s}, otherwise b_2 (or possibly some other design data) has to be changed. A smooth curve, often a simple circular arc but sometimes a shape with more curvature near the inlet, is now drawn conforming to the calculated blade angles β_1 and β_2, and the resulting blade channel is analyzed.

The blade channel should be shaped in such a way that the relative air flow decelerates gradually and at an even rate while passing through the blade channel, so that it will be smooth and free from turbulence and so that a conversion from velocity pressure into static pressure can take place with a minimum of losses. To check this, the following procedure is employed: Circles are inscribed at different stations (1, 2, 3, in Fig. 6) along the blade channel and the area of passage for the relative flow is determined at each station by multiplying the diameter of the inscribed circle by the blade width corresponding to the circle center. These areas of passage should increase at an even rate. By calculating the radii of equivalent circles (having equal area) and by plotting them against the center line of the channel, the shape of an equivalent cone can now be obtained; it should at all places have a cone angle of less than 6° with the center line, otherwise the design should be revised.

Scroll casing. A scroll casing, as shown in Fig. 2, 4, and 5, is used in most centrifugal fans and has two functions:

(1) To collect the individual air streams, leaving the fan wheel all along its circumference, and to reunite them into a single air stream discharging through the outlet opening.

(2) To provide a gradual deceleration of the air flow from c_2, the velocity at the wheel tip, to V_o, the lower velocity corresponding to the outlet area of the unit; the more even this deceleration is, the greater is the portion of the velocity pressure converted to static pressure and the higher will be the overall efficiency of the fan.

The first thought will be to make the scroll the shape of a spiral wherein the spiral angle should remain constant throughout and be equal to the angle a_2 at the wheel outlet (see Fig. 6). Such a casing would be very

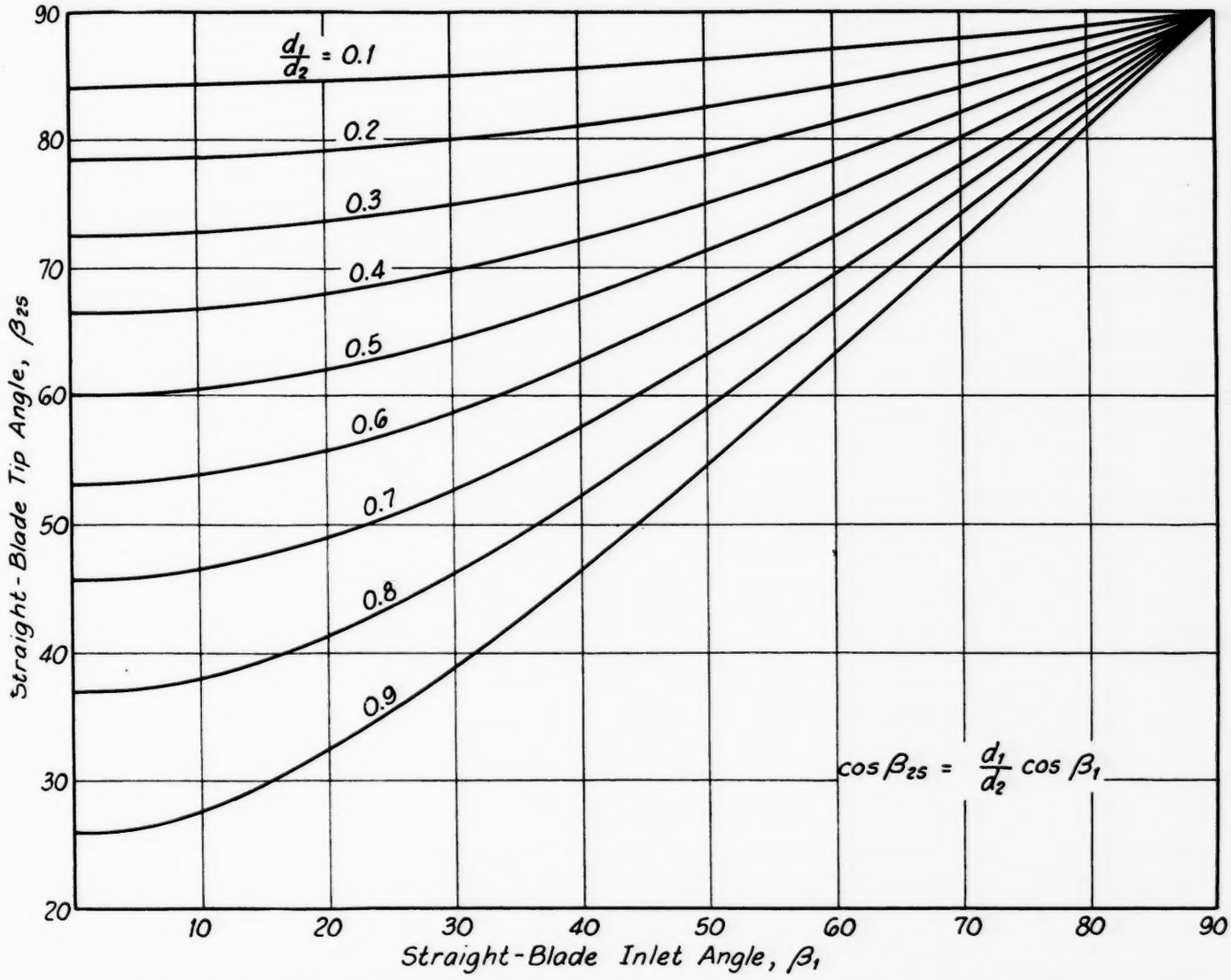


Fig. 7. Tip angle, β_{2s}, as function of the inlet blade angle, β_1, and of the diameter ratio, d_1/d_2, for straight blades.

efficient, but in most cases much too large for commercial use. The idea of a constant spiral angle, which leads to a logarithmic spiral, is therefore maintained, but the spiral angle is decreased to a "reasonable" value, which again is the result of a compromise between efficiency and compactness.

For narrow, low-volume fans, such as are used as pressure blowers, the following dimensions have become customary: The scroll angle is made about one half of the air angle α_2 at the wheel outlet. The casing outlet usually is the shape of a square or a circle and has a small area, resulting in a high outlet velocity, equal to about one half the air velocity at the wheel outlet. The resulting casing width usually is only slightly larger than the width of the fan wheel.

For wide, large-volume fans, the following dimensions have become customary: The outlet usually is the shape of a rectangle with a side ratio of 1.2 to 1.4 (the smaller side is parallel to the axis of rotation) and it has a large area, resulting again in an outlet velocity equal to about one half the air velocity at the wheel outlet. The inner edge of the outlet is placed near the center line of the fan. The resulting scroll is smaller (in comparison with the wheel diameter) than in the case of narrow fans, but the casing width is usually from 1.6 to 1.9 times the inlet width of the fan wheel. The latter is placed close to the drive side plate of the casing as this results in (a) somewhat more favorable outlet flow conditions and (b) a space saving arrangement for the inlet cone.

The inner edge of the rectangular outlet obviously has the function of a separator between the spiral flow in the scroll casing and the straight line flow through the outlet opening. As such it is subject to almost perpendicular impact by the air stream, much like the leading edge of an airfoil, and it is therefore extended to a streamline shape offering less resistance to that impact than a simple right-angle edge would do. This is done by mounting to the inner edge a formed sheet, called cut-off, which continues the scroll shape part way into the outlet opening. The customary dimensions, strictly the result of experimentation, are as follows: The cut-off extends to about 20% of the outlet opening and leaves a radial clearance to the wheel tip equal to about 10% of the wheel diameter.

Centrifugal Fan with Foward Blades

Let us now assume that the specifications led to the selection of a fan wheel with forward blades (Fig. 3c

and 8), having an outside diameter d_2 and running at a speed of n rpm. The design procedure will be similar to that outlined for backward blades, the design calculation, velocity diagram, etc. will be analogous. But a distinctive difference will be found in the fact that the air flow through the blade channels is far from being smooth; the air stream will not be able to follow the strong curvature of the blades, tangential conditions are no longer prevailing and the flow is inherently turbulent. For this reason, the design calculation will be even more dependent on empirical factors than in the case of backward blades. The resulting unit will have a lower mechanical efficiency, but —for the same size and speed—deliver much larger air volumes against higher pressures. Because the efficiency is here comparatively low anyway, slight manufacturing inaccuracies will not reduce it much further and will, therefore, be less objectionable than with backward blades; refinements such as overlapping at the inlet, sloping of the retaining ring, etc. can also be left out.

Inlet dimensions. By applying the same considerations as we have done for backward blades, we find that—due to the larger air volumes handled by forward blades—the diameter ratios d_1/d_2 are here larger, usually between 0.8 and 0.9. This results in the typical appearance of forward-blade fan wheels which always have large inlet openings and a narrow annular space left for the blades.

Since the air flow is turbulent anyway, a number of design features, which were used in backward-blade fans only for the purpose of smooth air flow and high efficiency, can be left out. There is no longer any reason for a narrow wheel with inlet acceleration; forward-blade wheels are, therefore, practically always built in large axial widths for maximum air delivery. The upper limit for the ratio b_1/d_1 is here about 0.65.

The outlet width, b_2, is made equal to the inlet width, b_1, so that the retaining ring is now simply a flat ring instead of a cone.

The overlapping lip as well as any curvature at the inlet edge of the retaining ring (for helping the air flow around the right-angle turn) are left out. Instead, the retaining ring is sometimes given an inside diameter slightly larger than d_1, so that portions of the blades extend beyond it which might somewhat improve the flow condition by leaving more room for the right-angle turn. The inlet clearance is made larger than for backward blades.

Velocity diagrams. As mentioned earlier, the blade angles are much larger than for backward blades, both at the inlet and at the outlet. The construction of the velocity diagrams (see Fig. 8) follows the same basic principles as for backward blades, but the procedure is somewhat complicated by the lack of tangential conditions. In other words, a considerable angle of attack has to be allowed as difference between the blade angle and the relative air angle; the numerical value of this angle of attack increases from the inlet to the outlet where it sometimes becomes as large as 20°.

As a result of the large outlet angle, β_2, larger than 90°), the circumferential component, c_{2u}, of the absolute air velocity at the wheel outlet will be very much increased so that the absolute air velocity, c_2, will be not much larger than its circumferential component and the angle between the two vectors will often become very small. While the large inlet angle, β_1, is mostly responsible for the large air volumes handled by forward-blade fans, the large outlet angle, β_2, (and the resulting large value for c_{2u}) is mostly responsible for the increased pressure produced.

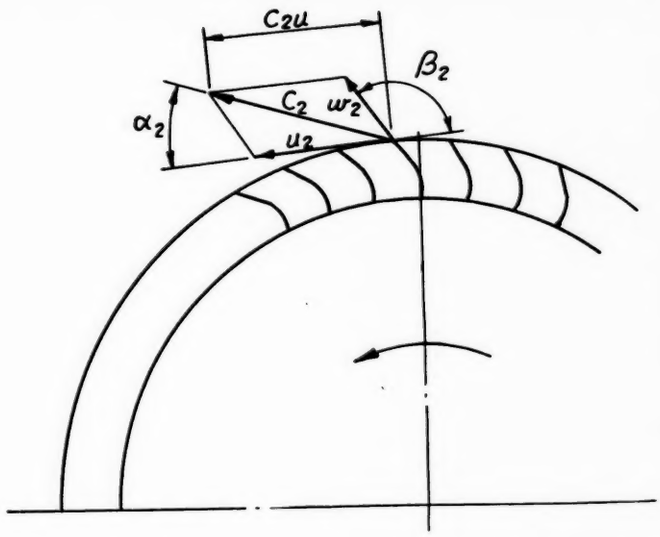


Fig. 8. Outlet velocity diagram for a forward-blade wheel.

Number and shape of blades. By applying again the considerations outlined for backward blades, we find that the increase in the diameter ratio d_1/d_2 and in the blade angles calls for a greater number of blades, usually between 40 and 60. In other words, the blade channels are so much shorter that they may be made considerably narrower.

The blade shape is now again selected as a smooth curve, furnishing the calculated blade angles at the inlet and outlet. Often a simple circular arc is used, but especially for larger-size fans a shape with more curvature near the inlet is of advantage, as it tends to reduce two harmful effects:

(a) It increases the area of passage near the inlet of the blade channel, which relieves an otherwise choking effect on the air delivery. Too small an inlet blade angle has the same effect and must, therefore, also be avoided.

(b) A strong curvature near the inlet, changing into a slight curvature toward the outlet, results in a desirable radial distribution of the blade angles, whereby the higher values are reached closer to the inlet than would be the case, were a circular arc used. The air is therefore likely to receive more circumferential motion by the rotating blades and the difference between the air angle and the blade angle at the outlet is consequently reduced.

The requirement that the relative air flow should gradually decelerate while passing through the channel, will often have to be dropped for forward blades.

Scroll casing. As has been mentioned, the scroll casing for backward-blade wheels was developed by adopting the logarithmic spiral as a basis and by de-

termining experimentally the smallest spiral angle that would still be tolerable in view of the mounting performance losses. It was natural to try forward-blade wheels in the scroll casing thus obtained for wide backward-blade wheels of the same diameter; experiments proved that the combination was satisfactory. This discovery was most welcome from the viewpoint of standardization and economy of production: Today most fan manufacturers use identical scroll casings for both types of wheels.

Centrifugal Fan with Radial-Tip Blades

Several applications of the radial-tip blade have been developed. The most important application of wide, radial-tip blades with inlet curvature (see Fig. 3E) is in mechanical draft fans. There are a number of reasons why this type of blade is selected for this type of duty:

(1) The specified pressures are often too high for backward-blade fans, but obtainable with radial-tip blades.

(2) The radial-tip "self-cleaning" feature is an advantage in the presence of dust and fly ash, especially in the case of induced draft.

(3) The efficiencies of these fans are almost as good as for backward-blade fans and high efficiencies result here in considerable savings since these are powerful units frequently used for continuous service.

(4) The radial-tip blade results in a steadily rising pressure curve and therefore in stability of performance even for parallel operation which is frequently encountered in mechanical draft. (This requirement would also be fulfilled by backward blades, but not by forward blades). It also results in a steeper pressure curve than a forward-blade fan, which is desirable in view of the fluctuating operating conditions (air deliveries will remain more nearly constant despite pressure fluctuations).

In most respects, these units take a place between the wide backward-blade and the forward-blade fan; to be more definite, they are somewhat closer to the first type. This holds true not only for the shape of the blades, but also for the various other design features and for the resulting performance. The inlet is again equipped with a converging inlet cone and the diameter ratio d_1/d_2 is here between 0.7 and 0.8. The amount of inlet clearance and the permissible range of inlet widths are practically the same as for backward blades; the narrow widths of this range are preferred, whenever possible, as they result in steeper pressure curves. The retaining ring is again sloped for optimum channel dimensions. The number of blades is between 16 and 28. Both the housing width and the outlet openings are somewhat smaller than they are for backward blades. The following additional features should be mentioned: Double-width, double-inlet units are very popular for this type of fan; inlet boxes are usually provided, especially for induced draft. Renewable wearing plates, fastened to the pressure side of the blades, and interchangeable scrolls or scroll linings are sometimes used; and the bearings are often water-cooled.

The wide, radial-tip blade, furthermore, is used in so-called steel plate fans. These are rather heavy units whose main advantages are ruggedness, simplicity and comparatively low first cost. They usually have from 6 to 12 straight radial blades with no inlet curvature which are mounted on heavy spider arms so that back plate and retaining ring often are eliminated. The air flow is, therefore, turbulent and the efficiency comparatively low. The inlet cone is also left off and the inlet is simply an angle iron ring for connection to the inlet duct. The housing width is somewhat smaller than that of backward-blade fans and the outlet opening is rectangular or square and smaller than that of backward-blade fans which results in higher outlet velocities. Inlet and outlet area are equal as a rule. Due to the radial tip, the pressures produced are higher than for backward-blade fans of the same size and speed, and due to the rugged construction the maximum running speeds are rather high and the fan can withstand severe service conditions. As these units are often employed for conveying materials, such as grinding dust, saw dust, cotton, grains and shavings, the straight shape and the wide spacing of the blades are an advantage, since curved blades and narrow passages would tend to become plugged up by deposits of dirt or of the material conveyed.

The most important application of narrow, radial-tip blades is in pressure blowers and turbo-blowers, such as shown in Fig. 9. These are high-speed units with capacities that are low compared with the pres-

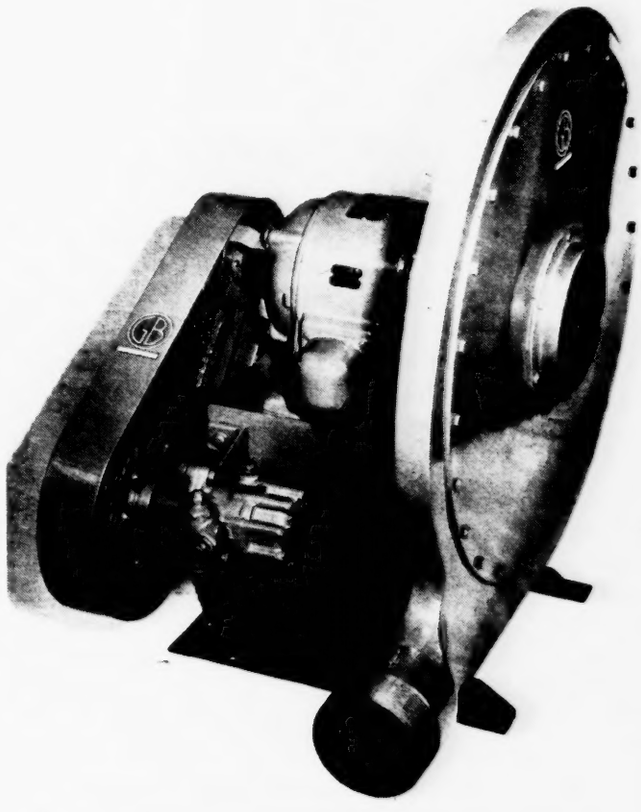


Fig. 9. Single stage turbo-blower with narrow radial-tip blades (General Blower Co.)

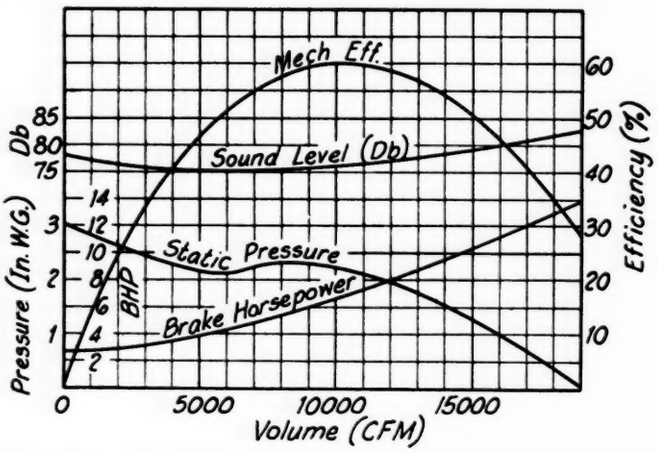


Fig. 10. Performance curves of a typical, backward-blade, centrifugal fan. Wheel diameter, 27 in.; speed, 1140 rpm.

sures produced. Inlet and outlet openings are small so that the corresponding inlet and outlet velocities are high. The inlet is sometimes just a simple circular ring for connection to the inlet duct, but sometimes (especially in high-power units) it is a streamline venturi-shape. The diameter ratio d_1/d_2 is between 0.2 and 0.5 and depends again on the specified capacity. The outlet opening is of circular or rectangular shape and its area is equal to or slightly smaller than the inlet area. The wheel is narrow so that the requirement of inlet acceleration is met as a rule and the blades are either of constant width or slightly sloped. These units are mostly employed for exhausting dust and fumes, for pneumatic conveying and for delivering air for combustion. They are also built as multi-stage units for refrigeration, scavenging, supercharging, and gas boosting; as such they sometimes produce pressures far in excess of 1 lb per sq in. (27.7 in. w.g.) and are then called compressors rather than fans or blowers. These high-pressure, high-power executions usually are designed for high efficiency, because of the resulting power economy this is accomplished:

(a) by correct design (sometimes backward blades are employed instead of radial-tip blades; this tends to improve the efficiency, but to reduce the compression ratio per stage and consequently to increase the necessary number of stages)

(b) by perfectly streamlining the air path all the way through the unit and by using accurately machined castings rather than sheet metal assemblies.

The Standard Test Codes, prepared jointly by the NAFM and the ASHVE, recommend five different test set-ups for centrifugal fans: Two set-ups for blowing through an outlet duct, one for exhausting from an inlet duct, one set-up with inlet and outlet duct, and one for exhausting from a chamber. In a specific case, the test set-up closest to the prospective application should be selected.

The test system used is then modified by applying throttles of varying degrees; different operating conditions (system characteristics) are thereby established. Running speed, pressure, electrical input, and density of the test air are measured for each condition, so that after subsequent calculation the characteristic curves of the fan can be drawn. For proper identification, the type of test set-up used should be marked on the performance curve sheet.

Shape of Performance Curves

Fig. 10 shows the general shape of the performance curves for a typical backward-blade fan having a 27-in. wheel diameter and running at 1140 rpm. Four curves are plotted against volume output, showing the variation of the static pressure, brake horsepower, mechanical efficiency and sound level for varying

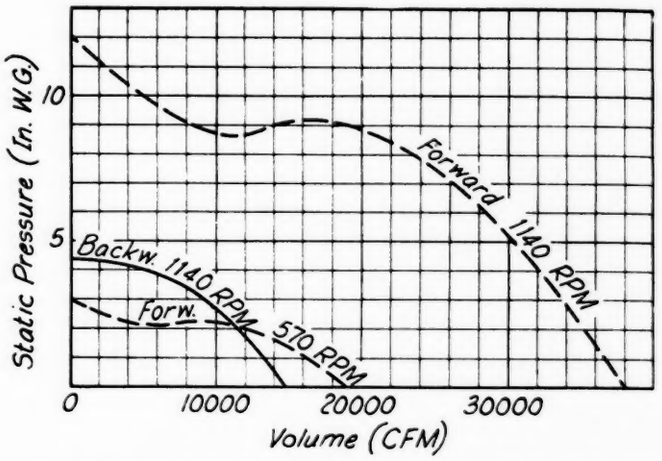


Fig. 11. Comparison of pressure curves for backward- and forward-blade fans. Wheel diameter, 27 in.

volume. The following characteristics are to be noted in the shape of such performance curves.

Pressure. Starting at the free-delivery point and going through the point of design (which is also the point of maximum efficiency) the pressure curve reaches a maximum value of 110 to 140% of the design pressure. Close to the no-delivery point, there is sometimes a slight pressure drop (as indicated by the dashed line), but apart from this, the pressure curve is of steadily rising shape and free from dips such as usually occur in the pressure curves of forward-blade fans and of vaneaxial fans; this characteristic results in stability of performance which makes backward blades (and radial-tip blades which also have this type of a pressure curve) most suitable for certain applications, such as fluctuating systems, parallel operation, etc.

Brake horsepower. The brake horsepower curve is of the so-called non-overloading type which again is a distinct advantage of backward blades. The curve reaches its peak in the range of maximum efficiencies, i.e. near the point of design, or somewhat to the right of it; the motor horsepower is then selected equal to this peak value and an overloading of the motor is therefore impossible.

Efficiency. The efficiency curve has its maximum at the point of design. Usual are maximum efficiencies of 75% for backward-blade fans, as compared with

60% for forward-blade fans and 85% for vaneaxial fans. In rare cases, maximum efficiencies of 80% are obtained for backward blades, 65% for forward blades and 90% for vaneaxial fans.

Sound level. This curve has its minimum in the neighborhood of the point of design, as could be expected, since it is in that range where the flow conditions are smoothest and most nearly tangential. For larger and smaller air deliveries, the sound level is somewhat increased, but this variation is smaller than it is with other types of fans.

Fig. 11 shows a comparison of three pressure-volume curves, all referring to centrifugal fans of 27-in. wheel diameter. Note that the scales used for pressure and for volume are here reduced to one half the values of Fig. 10. The full line is for the backward-blade fan running at 1140 rpm which was shown in Fig. 10. The two dashed lines are for a typical forward-blade fan running at the same speed and at half the speed, respectively. It is seen that for equal size and speed, the forward-blade fan delivers considerably larger volumes against much higher pressures. If the speed of forward-blade fan is reduced to one half, the operating ranges are not quite the same, but they are at least comparable. For this reason, forward-blade fans will in most applications operate at lower running speeds than backward-blade fans.

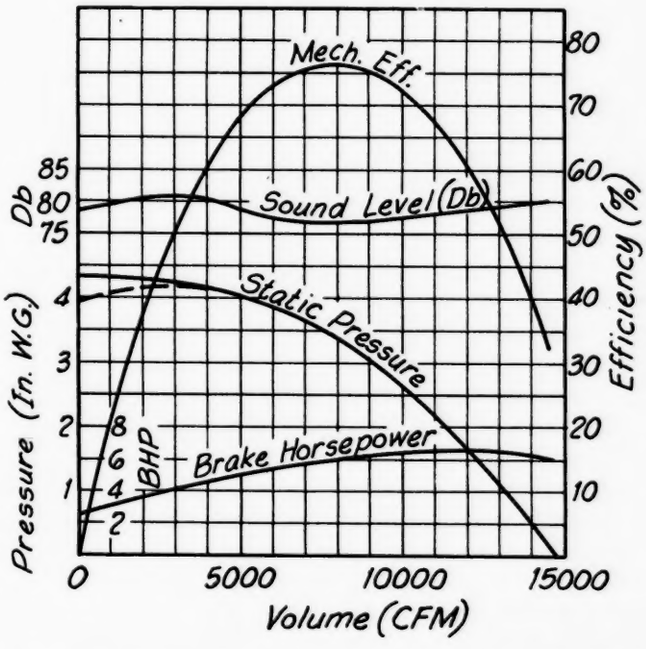


Fig. 12. Performance curves of a typical forward-blade centrifugal fan. Wheel diameter, 27 in.; speed, 570 rpm.

Another difference is found in the shape of the pressure curves: The curve for the forward-blade fan (dashed line) has a dip which in certain types of installations may cause unstable operation. Therefore, precaution should be taken so that forward-blade fans are not used for applications such as fluctuating systems or parallel operation and that even in other installations the unit does not operate in the unstable range of the pressure curve.

Fig. 12 (in which the same scales are used as in Fig. 10) shows the shape of the four performance curves for the typical forward-blade fan having a 27-in. wheel diameter and running at 570 rpm. Analyzing the performance of this forward-blade fan and comparing it with the performance of the backward-blade fan, we find the differences in the pressure curves and in the efficiencies which we have already pointed out and two other characteristics that are certainly worth mentioning.

Brake horsepower increases rapidly with increasing volume and therefore reaches a maximum at free delivery which is often as high as twice the brake horsepower in the range of maximum efficiency. Since centrifugal fans in general are not built for operation at or near free delivery (propeller fans or axial flow fans perform this function with greater efficiency), this shape of the brake horsepower curve results in power requirements outside the operating range that are higher than those within the operating range. This overloading brake horsepower curve is a great disadvantage of forward-blade fans. In small units, an oversize motor with a horsepower rating equal to that maximum brake horsepower usually is selected so that operation at any condition is safe. For large units, however, the increased price of the oversize motor would be prohibitive and the motor horsepower is selected only slightly larger than the brake horsepower for the prospective operating condition; precaution must then be taken so that the unit when installed in the field does not operate against too low a static pressure as this would result in an overload of the motor. (The permissible operating range of the forward-blade fan, being limited to the left by the dip in the

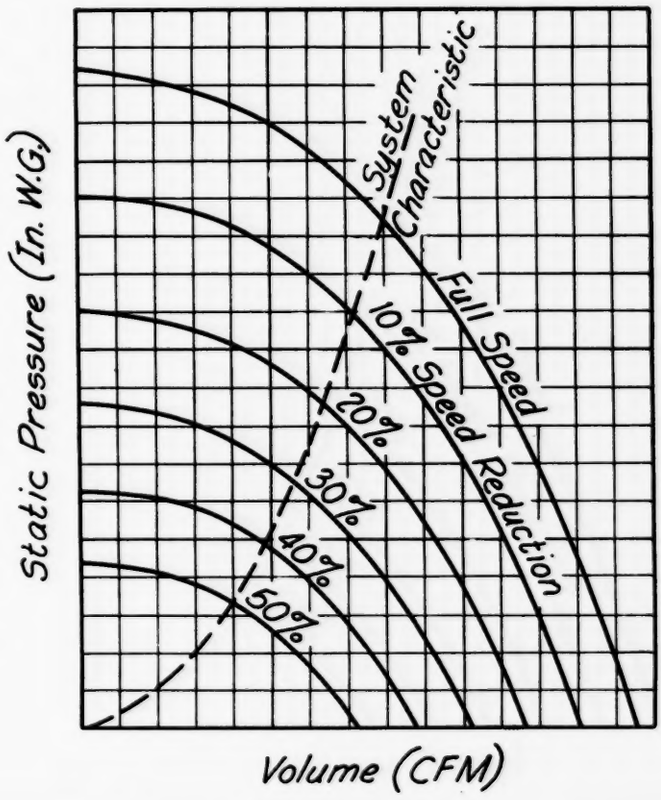


Fig. 13. Volume control by variable running speed.

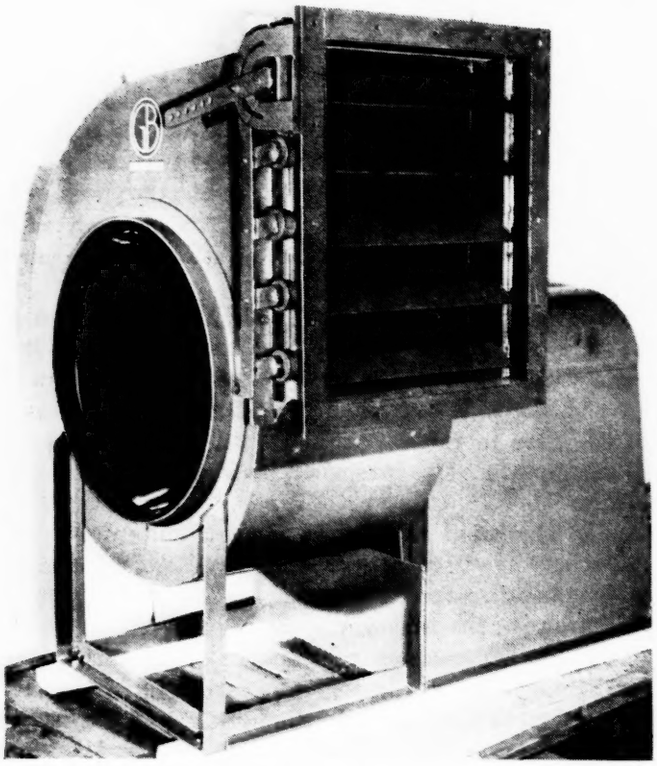


Fig. 14. Adjustable outlet damper. (General Blower Co.)

pressure curve and to the right by the rising brake horsepower curve, is therefore much narrower than that of the backward-blade fan).

Sound level again has its minimum in the range of maximum efficiency. For equal size and speed, the noise produced by forward-blade fans is much higher than for backward-blade fans, as could be expected in view of the increased capacities and inherently turbulent flow in forward-blade fans. This noise increase is so great that even at 570 rpm, the noise produced by the forward-blade fan is still of about the same level as the noise produced by the backward-blade fan at 1140 rpm. In other words, at comparable operating speeds, the noise levels of the two types are comparable.

Summarizing, we may say that the backward-blade fan has the following advantages over the forward-blade fan:

(1) Steadily rising pressure curve and the resulting stability of operation.
(2) Non-overloading brake horsepower characteristic.
(3) Higher mechanical efficiency.
(4) Higher operating speeds which, in directly driven units, often result in less expensive motors.

The forward-blade fan has the following advantages over the backward-blade fan:

(1) Slight manufacturing inaccuracies can be tolerated.
(2) Where space is limited and compactness is desirable, the forward-blade fan is often indicated, since by increasing its running speed to a still reasonable value a greatly increased air horsepower output (aerodynamical load) can be effected. With backward-blade fans, a corresponding increase of the already higher running speed might result in speeds necessitating reinforced wheels and special balancing methods. In such cases, the forward-blade fan is not only more compact, but at the same time less expensive, if only the first cost per cubic foot delivered per minute is considered.

From the above it appears that either type has its advantages for certain applications. The writer's opinion is that the advantages of the forward-blade fan will outweigh its disadvantages in small sizes and often even in medium sizes; in large sizes, however, the backward-blade fan will usually be preferable.

The performance of radial-tip blades, as might be expected, takes the place between backward blades and forward blades. For equal size and speed, the volume output and the pressure produced are greater than for backward blades, but smaller than for forward blades. For equal size and comparable operating range, the radial-tip fan will run at a medium speed. The same intermediate condition is true for the other performance characteristics such as brake horsepower curve, efficiency and sound level.

Sound Level

There are four sources of noise in a fan unit of any type. Vibration, mechanical, and electrical noise all can be reduced to a minimum by sufficient precaution. Aerodynamical noise is the main problem.

In a backward-blade centrifugal fan, the highest relative air velocity usually occurs at the leading edge of the blade, and correct design of this portion of the blade (tangential flow and the resulting condition of minimum turbulence) is of greatest importance for quiet operation. As in the case of axial flow fans, the sound level is affected by turbulence in the inlet air stream, but the sensitivity against inlet turbulence is here less than it is for axial flow fans. The reason for this decreased sensitivity is found in the fact that the air stream meeting the leading edge of a centrifugal fan blade is slightly turbulent already, from the 90° turn just performed; a little added inlet turbulence is therefore less noticeable than in the case of vane-axial fans that usually have a perfect inlet flow condition. This situation manifests itself also in the fact that for equal relative air velocities, the noise produced by centrifugal fans is of a higher level.

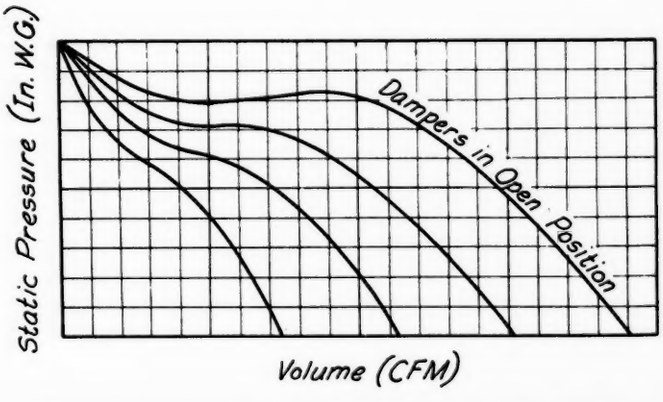


Fig. 15. Volume control by adjustable outlet dampers.

In the selection of fan speed, the permissible noise level is often the limiting factor; the decision between backward and forward blades, however, will in general not directly depend on the permissible noise level, since at comparable operating speeds, the noise levels of the two types are also comparable.

Volume Control

On many installations, the fan is selected for maximum output requirements, and means have to be provided so that the air flow can be reduced at times either manually or automatically. Three methods are in use to accomplish this reduction.

(1) *Variable running speed.* In the case of belt drive, this can be effected by interchangeable pulleys or by variable-speed pulleys. In the case of direct drive, variable-speed motors are used; this is frequently done in marine work. For large units, variable-speed hydraulic couplings, operating on the fluid-drive principle, are occasionally used. The effect of speed reduction upon the pressure-volume curve of a backward-blade centrifugal fan is shown in Fig. 13. The system against which the fan operates obviously is not changed by a variation of the fan's running speed; consequently the point of operation just moves along a parabola (dashed line in Fig. 13) representing the characteristic of a constant system. The fan efficiency remains unchanged and there is no danger of any shifting into an unstable performance range. Another advantage is that this method of flow reduction results in greatest power economy since the brake horsepower of a fan varies directly as the third power of the running speed. A third advantage is that due to the reduced running speed, the noise level is correspondingly reduced. The disadvantage of the method is that the first cost is usually high, especially if continuous variation is desired.

(2) *Adjustable outlet dampers.* A shutter-like mechanism, as shown in Fig. 14, is mounted on the fan outlet. The effect of this throttle on the pressure-volume curve of a forward-blade centrifugal fan is shown in Fig. 15. Compared with the two other methods, the savings in power consumption are somewhat smaller, but this method is the simplest in construction and the lowest in first cost. It is therefore the one generally used for flow reduction in small sizes where the effected power savings are small at any rate. For medium and large sizes, it shares the field with the two other methods.

(3) *Adjustable inlet vanes.* A set of vanes, each pivoting around a radial axis, is installed in the fan inlet. Their function is not so much to throttle the air flow (although this is also effected), as to impart to the entering air stream a spiral motion in the direction of the fan rotation, which results in a reduction of capacity, pressure and brake horsepower. As to both power savings and first cost, this method takes a place between the two others. Inlet vanes have the additional advantage of acting as air guides and thereby creating predetermined inlet flow conditions so that disturbances due to inlet turbulence, sometimes caused by inlet boxes, elbows, or other obstructions on the inlet, are eliminated or at least greatly reduced.

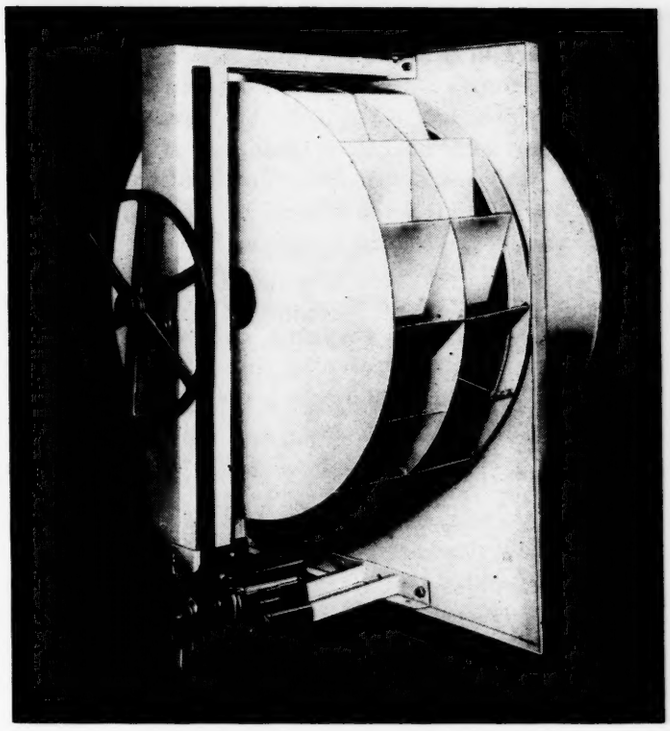


Fig. 16. Backward-blade centrifugal fan with circumferential discharge. (Eagle-Picher Co.)

Inlet vanes can also be used for boosting instead of reducing the output of a centrifugal fan. In this case, they naturally have to produce an inlet spin which is directed opposite to the fan rotation. This has been done occasionally on very large, belt-driven units such as are used for mine ventilation where, after years of successful operation, the ratings may have to be stepped up in order to meet changed conditions, caused, for instance, by an enlarged mine. If the running speed can not be increased, for structural or other reasons, it may be more economical to add a set of inlet vanes (even with a slight sacrifice in efficiency) rather than to tear down the whole structure and to replace it by a new fan unit.

Circumferential Discharge

Experiments show that in centrifugal fans of the backward-blade type, air delivery can be greatly increased by an increase of the scroll size beyond the limit permissible for commercial use. The maximum delivery is then reached when the scroll is of infinite size, i.e. when it is completely eliminated and a simple diffuser casing for circumferential discharge is substituted. The basic idea is by no means new, in fact the first centrifugal-type mine fans, installed about 100 years ago, were scroll-less exhausters with circumferential discharge.

Obviously such a unit can be used only for certain applications where the air is exhausted from a system of some kind and delivered into a large space, but in such cases circumferential discharge often proves superior to scroll discharge. Comparative tests reveal that with correct design of wheel and diffuser casing the free-delivery volume can be almost doubled, while

the maximum pressure may drop by 10 to 15%. The efficiency remains about the same, and the sound level curve is flattened out so that the useful range of operation is widened.

Optimum performance is obtained if the diffuser casing is designed for gradual deceleration of the air flow, resulting in reconversion of velocity pressure into static pressure. In practice, however, the unit usually is further simplified by elimination of the extended diffuser; this results in a moderate drop of capacity, pressure and efficiency, but even so the gain effected by the circumferential discharge is still very considerable. Fig. 16 shows a representative unit.

Application

The problem of fan selection for a specific application normally presents itself in the following manner: Air volume and static pressure are specified; a combination of type, size and speed is to be selected for optimum conditions.

For axial flow fans, a classification sheet, such as was presented in the earlier article, facilitates this selection. For centrifugal fans, a chart of this type would be too involved to be practical. Instead of presenting such a sheet, we shall give a number of typical examples illustrating the application of centrifugal fans:

(1) A centrifugal fan is to be designed for ship ventilation to deliver 10,000 cfm against 4 in. w.g. and to be directly driven by a 10 hp, 1140 rpm motor. The fan must under no condition overload the motor and the sound level produced must be less than 83 db. An analysis of the specifications for volume, pressure and motor horsepower reveals that an efficiency of 73% is required at the point of design. To obtain this efficiency, a backward-blade fan is selected. This type will at the same time fulfill the requirement of a non-overloading brake horsepower curve. We decide on a 30-in. wheel diameter. Converted (according to the general fan laws) to a 27-in. wheel diameter, this fan would deliver 7290 cfm against 3.24 in. w.g. By comparing these data with the performance curves of a typical backward-blade fan of the same size and speed, as shown in Fig. 11, we find that—in combination with the specified running speed of 1140 rpm—we have selected the correct size of a backward-blade fan to meet the volume and pressure requirements. The tip speed of this 30-in. fan at 1140 rpm will be 8960 fpm, indicating that—with correct design and good workmanship—we shall meet the sound level requirement, too.

If the fan were for installation in a noisy factory where the sound level requirement could be left out, we would select a 23-in. backward-blade fan at 1750 rpm. This fan would be less expensive due to the smaller size and higher motor speed, but at the same time it would have a higher noise level due to the considerably higher tip speed.

(2) An inexpensive fan is to be designed that will deliver 1000 cfm against 1.5 in. w.g. The fan is to be built into an industrial air heater and should be as compact as possible, as the space available is rather small; power consumption and noise level, on the other hand, are of only secondary importance. We elect to design an 8-in. forward-blade fan, running at 1750 rpm and blowing into the heating coils. Converted to 27 in. and 570 rpm, this fan would deliver 12,520 cfm against 1.81 in. w.g., which according to Fig. 13 falls well within the operating range of the forward-blade fan. A ¾-hp motor will be ample for the prospective operating condition, but a 1-hp motor will have to be selected if the free-delivery brake horsepower should also be covered.

(3) A double-width, double-inlet fan for induced draft is to be designed that will handle air at 610F at 700 ft altitude, and under these conditions is to deliver 47,000 cfm against 3 in. w.g.; the outlet velocity should be about 4500 fpm. The correction factor for standard air density (70F and sea level) is 2.07 and the converted specifications therefore read 47,000 cfm against 6.21 in. w.g. We elect to design a 44½-in. fan with radial-tip blades, running at 860 rpm. With a mechanical efficiency of 70%, this fan would absorb 78.8 hp at standard air conditions; by dividing by the correction factor 2.07, we find that at the actual operating conditions 38.1 hp will be sufficient; we therefore select a 40 hp motor.

(4) A pressure blower for exhausting the dust from a small grinding wheel is to be designed. It should deliver 300 cfm against 9 in. w.g. and have an outlet velocity of about 4000 fpm. We decide on a narrow wheel of 11½-in. diameter at 3500 rpm, having straight, backward blades with a tip angle of about 70°. With streamlined conditions at inlet and outlet, we can obtain a maximum mechanical efficiency of about 75%. With a simplified, low-cost construction, the efficiency will still be about 65%. A ¾-hp motor will safely cover the entire range.

(5) A turbo-blower for gas boosting is to be designed to deliver 2000 cfm against 2 lb per sq in. (55.4 in. w.g.); the outlet velocity should be about 3500 fpm. We decide on two narrow 21-in. wheels in series (double stage unit) at 3500 rpm, having straight, radial blades. A maximum mechanical efficiency of 65% can be expected. The point of operation will be in the range of maximum pressures, and the motor horsepower is selected somewhat larger than the brake horsepower at the point of operation; a 30-hp motor is thus required (while the maximum brake horsepower, occurring further toward free delivery, may be as high as 50 hp).

(6) A belt-driven fan is to be designed that can be built into a small apparatus and will pull a cooling air stream through some narrow passages and discharge it into the atmosphere. 60 cfm should thus be delivered against 0.6 in. w.g. Moreover, as a special requirement, the fan should be reversible and the same amount of air should be exhausted regardless of the direction of rotation—In view of the small quantities involved, efficiency and power consumption are, of course, of no importance. An ideal solution is found in a 5-in. fan wheel with straight, radial blades and circumferential discharge, running at 2500 rpm. Quiet operation, extreme compactness and draftless discharge are special features of the design.

The Heat Pump as a Hobby

CARL F. BOESTER

The author gives some practical suggestions on how to assemble your own heat pump unit for heating and cooling your own home. This article is the result of Mr. Boester's experience with a private hobby, and has no official connection with his position as Housing Consultant, Purdue Research Foundation.

DURING the past several years there has been greatly renewed interest in the heat pump. This has been the result of several causes, principal among which has been public response to the novelty of the idea of obtaining heat from the earth or outdoor air. To many engineers, this idea is not at all new, but economic application has not been widely feasible because the right equipment has not been available, and fuel or energy rates have not been favorable. Conditions are presently shaping up so that the heat pump is not only feasible but desirable. A compelling impetus, too, is the increasing demand for summer comfort with reduced first cost installation.

Many engineers would like to be brought up to date on recent design and application practices and to learn of current limitations. The best way to gain up-to-date experience is to undertake, in a modest, personal way, the design, installation, and operation of a heat pump unit in your own home or that of a friend. Having had several years' fun with just such experience, I am probably better qualified to suggest what has not worked rather than to recommend how to get started on a heat pump venture; but when one travels new territory, new maps are surely needed, so that I have the following to suggest.

Probably the first decision is the source of heat, which is the prime consideration in the heating cycle. I've had lots of experience with earth-buried heat exchangers and have no qualms at all about the use of the earth anywhere as a heat source. If you want to keep your experiment low in cost, however, you will use an existing residence and will not want to plow up half the back yard to bury coils. What about wells —wet or dry? They're okay and it can be done, but it's really tricky. In my opinion you had better try other methods first.

We still have air and water as sources for our tyro venture. Water is fine if you have plenty of it at low cost, but I believe an air-to-air system offers the lowest cost, the simplest and most efficient system, and the most challenging problems. A few readers will stop here with the plausible reasoning that it's too cold where they live for air-to-air heat pumps. In some cases that may be so, but generally I'd say the limitation might be that where this is so it's cool enough where you live so that summer cooling isn't needed. If so, forget about an air-to-air experiment; if not, then be assured that most all applications where summer cooling is desirable can be handled air-to-air.

It is suggested that gas, bottled or from the mains of your utility, be used as energy rather than electricity. How? By the use of a small *air cooled* internal combustion engine using gas instead of gasoline to drive your compressor. Requirements will be, say, 11 cu ft of 1000 Btu gas per horsepower hour. If the heat load requires a five horsepower compressor picked at a 20F suction temperature and a 110F discharge temperature, a gas engine of 10 hp will handle the job nicely. On rare occasions the compressor may operate at zero suction temperature or below. The engine will run, depending on conditions, at 3 to 10 hp.

The equipment must be assembled in some practical manner, so let's use a 1½ x 1½ in. angle iron frame mounted vertically seven feet high and 24 x 24 in. in plan. The equipment might be placed within the framework as indicated in Fig. 1. The frame will contain two fin coil heat exchangers, a blower, the compressor, engine and silencer muffler, filters and miscellaneous valves and controls.

The fin coils should be of ⅜-in. copper tube and preferably copper finned, six fins to the inch, and the coil eight rows deep in the direction of air flow. Three coils are needed, the third to be used in the house as the heating and cooling unit. A double inlet blower good for 1500 cfm at ⅝ in. static pressure should be used. Coils one and two are mounted in the frame. Coil three is in a separate cabinet with same size blower and filters and is placed inside the house for its heating and cooling.

All refrigerant gas piping should be 1⅛-in. copper with valves of the same size; refrigerant liquid line piping should be ⅝-in. copper. Fig. 2 is a diagrammatic sketch of the piping. A receiver is not required or practical, so the F-12 refrigerant charge is critical.

In the heat pump unit (Fig. 1) the engine belt drives both the compressor and blower. The frame of the heat pump unit is sheathed with weather and soundproof insulating board. Since outdoor air exclusively passes through this unit, naturally it is placed outdoors. As in-

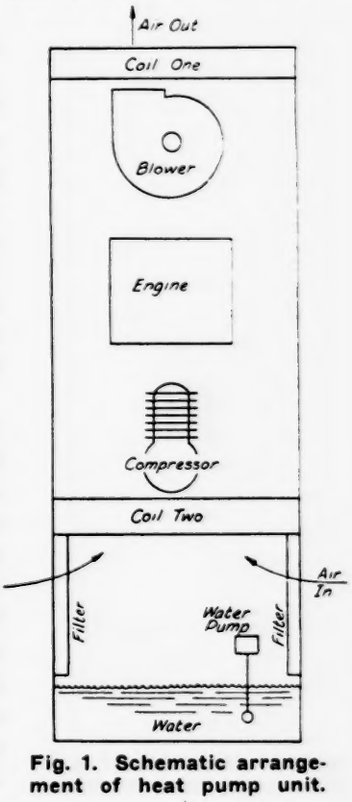


Fig. 1. Schematic arrangement of heat pump unit.

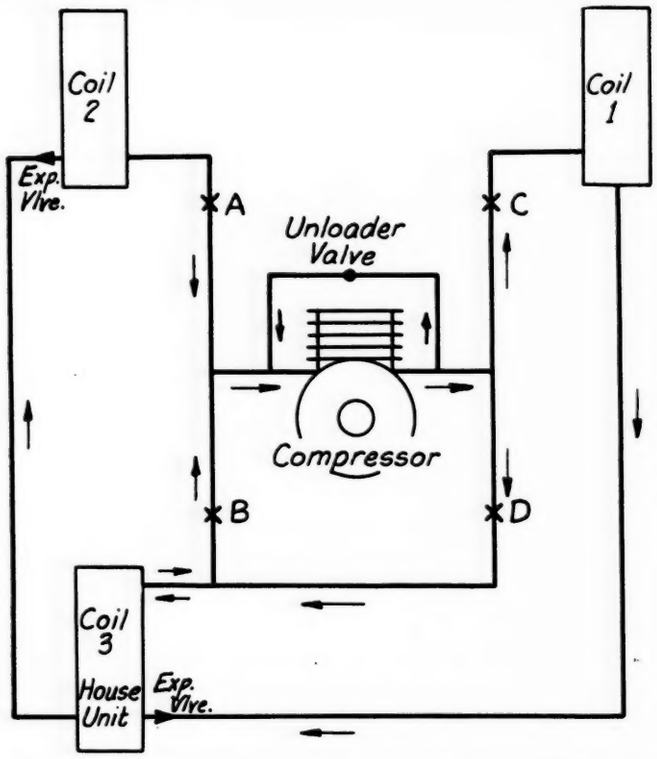


Fig. 2. Piping and general arrangement of complete system.

Valve Schedule

Winter—*A* and *D* open; *B* and *C* closed

Summer—*A* and *D* closed; *B* and *C* open

dicated, the base of the unit should have 24 x 24-in. fiber glass filters on all four sides. The bottom should be a four-inch water retaining pan. In summer a float valve keeps this full of water and a tiny pump keeps the filters wet so that the dry bulb temperature of the entering air is depressed by evaporative cooling before it passes over the air cooled refrigerant condensing coil.

The house conditioning unit is inside the house and connects with supply and return air ducts in the usual manner. Its fan runs all the time.

To save cost, and reduce maintenance problems, it should not be necessary to equip the engine with auxiliaries such as starter, generator, batteries, relays and the like. As a result, the engine will have to be cranked or rope started, as the idea is to keep the control simple. This implies that the engine will run continuously. Therefore, a thermostat controlled damper motor will operate the engine throttle so that the compressor speed will match the required load. When heating or cooling is not required, the thermostat has the engine throttle placed in idle position. At this point a mercury switch on the damper motor unloads the compressor by operating a solenoid valve in a by-pass from discharge to suction. The unloading solenoid valve must be of the manual operating type so that the compressor can be unloaded when the engine is cranked. The engine runs all the time in idle speed, the by-pass is open, and no heating or cooling work is done until the room thermostat repositions the damper motor. A double throw, double pole switch changes the thermostat from summer to winter. Since the engine operates on gas, there is no carbon formed, gummed valves, or crankcase dilution so that the engine runs with little maintenance. Hand valves inside the heat pump unit switch it from winter to summer cycle or the reverse as required. The cycle and position of the valves is indicated in Fig. 2.

Multi-outlet expansion valves with insert remote bulbs should be used on coils two and three, and the valves should be gas charged. Coil two is an evaporator used only in the winter cycle. Coil three is an evaporator in summer or condenser in winter. Coil one is the air cooled condenser on the summer cycle. Coil two picks up most all the engine heat when used as an evaporator on the heating cycle. It also picks up the heat of outdoor air. The engine heat keeps frost off this coil. About one-third of the engine heat is shaft work picked up as heat of compression. The heat from the air cooled engine is in the air stream over coil two as is the heat in all exhaust gas.

All good practices such as the use of driers and filters in the refrigerant lines should be observed. Heat exchangers (gas to liquid refrigerant) may be advisable but use them only if you know where and how.

A hypothetical operating condition of 30F outdoor air and a 7-hp load should yield about 120,000 Btu per hr. This is more than enough for the average home.

This heat pump unit can be boosted in winter heat capacity by placing a plain, gas-fired, side-arm type water heater in the bottom filter section so as to add heat to the refrigerant; feed liquid refrigerant from the liquid line of coil three to a capillary tube into the top of the heater and hook up the bottom outlet to the outlet line of coil two. This gives counter flow of refrigerant to the products of combustion from the heating gas. Most of this flue gas heat is picked up in coil two. Solenoid valves should be placed on the inlet and outlet of this booster heater. An outdoor air low limit switch should operate the gas fuel supply valves as well as the refrigerant valves of the heater.

Except when the heat requirements exceed the evaporator yield, this heat exchanger will not be needed, which may be the case in 90% of the time in 90% of the places. If your house has only 70 or 80 thousand Btu heat loss it should never require added heat. Needless to say, if the unit will carry the heating load it will carry the cooling load. A guesstimate is that the engine running all day every day will consume an average of 30 to 40 cu ft of gas per hour. To my mind, this is a reasonable operating cost.

A tremendous amount of fun and experience can be gained by building and operating your own heat pump. If you do the work yourself, a thousand dollars seems a generous budget, a cheap education, and an inexpensive hobby.

Anyone using the foregoing ideas to build one such unit for themselves is welcome to do so. If a business around such ideas is contemplated, there are, of course, patents and patent applications to be considered. If the foregoing discussion isn't adequate, don't attempt a heat pump until you are well grounded in fundamental details you should know, such as blower or compressor speeds, and so on. If you think my assumptions or recommendations are in error or you can top the suggestions, please write me; I'm still learning, too.

SELECTION OF V-BELT DRIVES

Belts of the V-type provide a compact, resilient transmission and they have been applied extensively to drives for fans, generators, water pumps, and many miscellaneous types of machines and industrial transmissions. Only the angular sides of a V-belt should be in contact with the sides of the pulley groove. The belt is approximately flush with the top of the pulley and the pulley groove should be deep enough to provide a clearance space at the bottom of about $\frac{1}{8}$ to $\frac{3}{16}$ inch to insure a belt contact at the sides only. A multiple V-belt drive is commonly used instead of a single belt when required to increase the power-transmitting capacity. The driving and driven pulleys of these multiple drives are grooved for each belt, the grooves being spaced to provide a little clearance between the different belts.

Industrial V-belts are standardized in five cross-sections, the dimensions of which are given in Table 1. The included angle between the sloping edges of these belts is approximately 40°.

Selection of industrial V-belts is a procedure standardized by the Rubber Manufacturers Association and the following is summarized from the standard method and presented here through the cooperation of the Association. More definite information about the power transmitting capacity of a given type or make should be obtained from the manufacturer.

In most problems of V-belt selection, the rpm of the driving and driven shaft, horsepower of motor, and distance between shaft centers are known. The subsequent steps are based on these known points.

Step 1. Each type of application and motor has characteristics on which the peak belt capacity is based. Consequently, multiply the motor horsepower by the proper multiplier or service factor given in Table 2.

Step 2. Having found the corrected or normal horsepower, enter Table 3 and find the recommended belt section.

Step 3. Calculate the speed ratio by dividing the rpm of the high speed shaft by the rpm of the low speed shaft.

Step 4. Determine the pitch diameter (d) of the small sheave. This can be selected arbitrarily from manufacturers' data with the restriction that the sheave should not be smaller than listed in Table 1, and slightly larger if there is no limitation.

Step 5. Determine the pitch diameter (D) of the larger sheave by multiplying d by the speed ratio obtained from Step 3.

Step 6. Find the length of the belt by the following formula:

$$L = 2C + 1.57(D + d) + \frac{(D - d)^2}{4C}$$

where all dimensions are in inches, L = belt length, C = center-to-center distance, and D and d are the pitch diameters. The best center distance is approximately equal to or greater than D.

Step 7. For the determined belt section and length refer to stock size tables of V-belts available from manufacturers.

Step 8. Select the nearest standard belt from stock size tables of V-belts available from manufacturers. If this is reasonably close (2%) take $\frac{1}{2}$ the difference between this and the calculated length and adjust the center distance used in Step 5 for the center distance to be used. If the exact centers are needed, refigure with this new center adjusting again as above.

Step 9. The horsepower which can be carried per belt depends on the section size, arc of contact of smaller sheave, and belt speed. The belt speed (V) in feet per minute is

$$V = d \times \text{rpm of motor} \times .262$$

Step 10. Knowing the section from Step 2, belt speed from Step 9 and pitch diameter d from Step 4, enter Table 4 and determine the nominal horsepower per belt or small sheave for 180° arc of contact.

Step 11. Find the arc of contact on small sheave by solving the formula:

$$180° - \frac{60(D - d)}{C}$$

where C is the exact distance from Step 8.

Step 12. Refer to Table 5 for the arc of contact correction factor, interpolating if necessary.

Step 13. Multiply the nominal horsepower from Step 10 by the correction factor from Step 12, finding the adjusted horsepower per belt.

Step 14. Divide the normal horsepower from Step 1 by the figure from Step 13 to find how many belts are required.

Example. A 1 hp. 1750 normal torque line start squirrel cage motor is to drive a centrifugal fan at 400 rpm. On center distance is to be 34 inches ±1 inch. Select a V-belt.

Solution. 1. From Table 2, multiplier is 1.2. Thus $1.2 \times 1.0 = 1.2$

2. From Table 3, for 1750 rpm and 1.2 hp., find section A.

3. Speed ratio = 1750/400 = 4.375

4. Select d as larger than 2.6 (Table 1); call it 3.4 inches

5. Then $D = 3.4 \times 4.375 = 14.9$ inches.

6. $L = (2 \times 34) + 1.57\,(14.9 + 3.4) + \frac{(14.9 - 3.4)^2}{4 \times 34}$

L = 97.7 inches, length of belt

7. From catalog, nearest stock size in A section is 97.1 inches

8. This is within 2%. Belt is shorter than required. $97.7 - 97.1 = 0.6$ and $\frac{0.6}{2} = 0.3$. Correct center-to-center distance should be $34.0 - 0.3 = 33.7$ inches.

9. Belt velocity is $3.4 \times 1750 \times .262 = 1559$ fpm

10. From Table 4, under A, under 3.4, opposite 1500 find 1.1 horsepower per 180°.

11. Arc of contact $= 180° - \frac{60(14.9-3.4)}{33.7} = 159.5°$

12. From Table 5, for 160°, correction factor is 0.95

13. Multiply 1.1 (Step 10) by 0.95 = 1.045 horsepower per belt

14. $\frac{1}{1.045}$ is slightly under 1, so that 1 belt will suffice. This belt will be section A, 97.1 inches long. Motor sheave will be 3.4 inches p.d., fan sheave 14.9 inches p.d.

Table 1. Dimensions of V-Belts and Sheaves

Designation of Cross Section	V-Belt Dimensions, Inches		Sheave Dimensions, Inches				
					Pitch Diameters Available		Add to P.D. to Obtain Outside Diameter
	Width at Top	Depth or Thickness	Groove Spacing	Min. Recommended Pitch Dia.	Stock	Non-Stock	
A	1/2	11/32	5/8	2.6	3.0 to 6.4 in 0.2 in. increments; 7.0, 8.2, 9.0, 10.6, 12.0, 15.0, 18.0	3.0 to 36.0 in 1 in. increments; 38.0 and 40.0	3/8
B	21/32	7/16	3/4	5.0	5.0 to 7.0 in 0.2 in. increments; 7.4, 8.6, 9.4, 11.0, 11.4, 13.6, 15.4, 16.0, 18.4, 20.0, 25.0, 30.0, 38.0	7.0 to 36.0 in 1 in. increments; 38.0 to 60.0 in 2 in. increments	1/2
C	7/8	17/32	1	7.0	9.0 to 10.2 in 0.2 in. increments; 10.6, 13.0, 16.0, 20.0, 24.0, 30.0, 36.0, 44.0, 50.0	11.0 to 36.0 in 1 in. increments and 38.0 to 72.0 in 2 in. increments	3/4
D	1 1/4	3/4	1 7/16	12.0	13.0 to 15.4 in 0.4 in. increments; 18.0, 22.0, 27.0, 33.0, 40.0, 48.0	14.0; 16.0 to 36.0 in 1 in. increments; 38.0 to 96.0 in 2 in. increments	7/8
E	1 1/2	1	1 3/4	20.0	None	20.0 to 36.0 in 1 in. increments; 38.0 to 96.0 in 2 in. increments	1 1/8

Table 2. Service Factors for Various V-Belt Applications

Application	Type of Motor								
	Squirrel Cage			Wound Rotor	Synchronous		Single Phase		D.C. Shunt Wound
	Normal Torque Line Start	Normal Torque Compensator Start	High Torque		Normal	High	Repulsion and Split Phase	Capacitor	
	Service Factor (Multiplier)								
Centrifugal fan	1.2	1.2	—	1.4	—	—	—	—	1.2
Propeller fan	1.4	1.4	2.0	1.6	—	2.0	—	—	1.4
Induced draft fan	1.2	1.2	—	1.4	—	—	—	—	1.4
Positive blower	1.6	1.6	—	2.0	2.0	2.0	—	—	—
Centrifugal compressor	1.2	1.2	—	1.4	1.4	—	—	—	1.2
Rotary compressor	1.2	1.2	—	1.4	1.4	—	1.2	1.2	1.2
Reciprocating compressor (3 or more cyl.)	1.2	1.2	—	1.4	1.4	—	—	—	1.2
Reciprocating compressor (1 or 2 cyl.)	1.4	1.4	—	1.5	1.5	—	—	—	1.2
Centrifugal pump	1.2	1.2	1.4	1.4	—	—	1.2	1.2	—

(Tables 3, 4 and 5 will appear on next month's data sheet)

How the Higher Courts Have Ruled

Review of new law suits of interest to the contractor and employer

LEO T. PARKER
Attorney-at-law, Cincinnati, Ohio

RECENTLY a reader wrote:
"I have a law suit on my hands. I am a heating contractor. A dwelling owner sued me for heavy damages claiming that I defrauded him by installing a heating system that smoked, ruined the inside of his home and would not heat his house. He claims I defrauded him because I distributed circulars furnished by the manufacturer which falsely represented the heating unit. Can you assist me to win this suit?"

It is certain that you are liable in damages to the home owner if the heating unit did not conform to your guarantee. However, the fact that you distributed the manufacturer's circulars which misrepresented the unit will not make you liable, unless the home owner proves that he read these circulars before he made the contract with you.

In other words, you are not liable unless (1) you breach your contract or guarantee; or, (2) you practiced fraud on the property owner.

For example, Dobbins v. Pacific Coast Coal Co., 170 Pac. (2d) 642, reported recently, the testimony showed:

One Dobbins purchased a newly constructed dwelling house from a contractor and builder. The heating unit not only failed to adequately heat the premises, but deposited a film of soot on the interior walls and the furniture and fixtures in the various rooms.

Dobbins sued both the contractor and the manufacturer for damages. Dobbins proved that the furnace would have to be removed, and some other heating unit installed, at a cost of $1,450. He asked the court to award damages of $1,450 plus additional damages for injury to the walls, furniture and fixtures of the house. Dobbins contended that the contractor was liable because he distributed circulars which misrepresented the heating unit. Each circular was full of representations such as: "New heating efficiency," "amazing furnace," "less fuel," "ideal for houses," and many others to the general effect that the furnace would be most satisfactory for small houses.

The higher court refused to hold the contractor liable because the property owner failed to prove that he had read the circulars before he purchased the house. This court said:

"There is no evidence whatever therein that the plaintiff (property owner) saw the circular until long after he had purchased the Tucker house. It is, therefore, obvious that no finding of fraud could be predicated on any representation even if false. Proof of reliance upon a false representation is an indispensable element in a fraud action."

The higher court refused to hold the manufacturer liable because he proved that the furnace was one of a great number of patented furnaces of identical design, manufactured by the company after the design had been tested and officially approved by the Federal Bureau of Standards, and by the engineers of the Federal Housing Authority.

This court also held that no contractor is liable for fraud unless the property owner proves these facts: (1) You made a representation of an existing fact; (2) It was a falsity; (3) You had knowledge of its falsity or ignorance of its truth; (4) You intended that it should be acted on by the property owner to whom it is made; (5) The property owner was ignorant of its falsity; (6) The property owner relied on the truth of the representation, with consequent damage.

Failure of the property owner to prove *all* of these facts will result in your not being liable for damages, on basis of fraud, although the installed heating unit is inefficient in every respect.

Employe Denied Compensation

All courts agree that where the Industrial Commission refuses compensation to an employe, considerable burden is placed upon such employe to prove that he is entitled to compensation.

For example, in Updegrove v. Floyd Wells Stove Co., 49 Atl. (2d) 870, an employe of the Floyd Wells Stove Co. sued asking the court to reverse the Industrial Commission which refused to award compensation for total disability as a result of anthraco-silicosis contracted while in the company's employ. The company denied that the alleged disability was caused by anthraco-silicosis or any occupational disease. Also, the Commission decided that the employe was totally disabled; and that he was afflicted with "minimal silicosis", the cause of which had not been proven. The higher court also refused to award compensation, saying:

"Careful consideration of the medical testimony convinces us that the claimant (employe) failed to prove beyond conjecture and conclusively that silicosis was the sole cause of his total disability."

National Labor Act

According to a recent higher court an employer violates the National Labor Relations Act, as an unfair labor practice, if he denies members of a labor union the same relative right or privilege accorded other persons.

In National Labor Relations Board v. American Furnace Co., 158 Fed. (2d) 376, the higher court held that an employer violates the National Labor Relations Act, as an unfair labor practice, if such employer prohibits an employe from distributing union

literature at relatively the same spot and time as anti-union literature was distributed by various other persons and employes.

Liability for Fire

Considerable discussion has arisen from time to time over the legal question: What proof or testimony is necessary to relieve a heating contractor from damage liability where a property owner claims that the contractor's negligent installation of a heating unit caused the building to catch fire and burn?

A good plan by which heating contractors may avoid all liability for damage caused by negligence alleged by the building owner is introduction of testimony which will convince a jury that the damage was not caused by negligence of the contractor, or his employes.

See the recent decision of Adams, 109 So. 804. Here the owner of a home sued a heating contractor to recover damages for loss of the building by fire. The property owner claimed that the fire was caused by negligence of the contractor's employes who installed a pipe so close to a wooden beam that it caught fire.

During the trial the contractor had a witness testify that for three and one-half hours he had left a piece of paper against the pipe, when the register was hot, and the paper did not catch on fire.

In view of this testimony the jury refused to hold the contractor liable for destruction of the building. The higher court approved the verdict.

Hence, a heating contractor can win a suit by introducing testimony which will convince a jury that damage or destruction to real or personal property was not caused by the contractor's negligence.

Also, see Jack, 42 Atl. (2d) 838, where a property owner sued a contractor for damages caused by fresh plaster falling from a ceiling inside the building. The higher court held the contractor not liable because there was no proof that the contractor's negligence caused the plaster to fall.

Also, see Pappas v. Parsons, 25 N. W. (2d) 510, reported July, 1947. Here it was shown that the Holmberg Heating and Air Conditioning Co. was employed to insulate a second floor ceiling with granulated rock wool. The building to be insulated had a flat roof running from west to east. It was a built-up roof consisting of roofing paper and tar composition. Holmberg and an employe who operates the blower proceeded to cut two ventilator holes about 12 by 18 in. in the front half of the building. They then insulated the ceiling with about 4 in. of rock wool. Soon after they left, the building owner saw smoke coming from the roof. The building was destroyed by fire. The property owner sued the air conditioning company and proved that sparks were emitted from the nozzle of the hose used in blowing the rock wool into the building. Also, proof was given that the nozzle was so hot that it could not be held without wrapping it in various materials.

Nevertheless the higher court refused to hold the company liable for the fire loss, saying:

"An analytical chemist analyzed a sample of the pellet type of rock wool used on the job and found that there was no cotton or wool in it; and that it consisted of mineral fibres made of blast furnace slag or limestone or silicate; that in passing through the hose it would not create friction sparks."

Contradictory Testimony

Under no circumstances should a heating or plumbing contractor perform work under a verbal contract. This is so because very frequently controversy and disagreement arise, and the contractor is compelled to file suit to collect the amount due. If the contractor is awarded a favorable verdict he must convince the court that his testimony is truthful.

For example, in Sallblad v. Burman, 29 N. W. (2d) 673, the testimony showed facts, as follows: The Burman Plumbing and Supply Co. made a verbal contract with a property owner to perform certain work and supply materials. Controversy arose over the amount due, and since the property owner refused any payment the plumbing company filed a mechanic's lien to recover $1,153.

During the trial the manager of the plumbing company testified that he was to be paid at the rate of $2.35 for each man-hour of labor, plus 20% of the total labor cost for supervision, and that the property owner agreed to pay him for materials furnished at retail cost. The property owner, however, testified that the agreement was that the plumbing company should furnish the materials at wholesale cost, plus 20%, and labor at $2.35 per man-hour, plus 5% of the labor cost for supervision. The property owner argued that he owed the plumbing company only $700.

The higher court believed the testimony of the manager of the plumbing company and held that the agreement was on a "cost of material and plus time" basis and that the reasonable value of the work and materials was $1,155.34, as alleged by the manager.

For comparison, see Druar v. Ellerbe & Co., 24 N.W. (2d) 820. Here suit was filed against Ellerbe and Company, an architectural firm, by an engineer to recover a share of profits earned by the former. The engineer alleged that they agreed to pool their abilities and facilities and use their best efforts to secure profitable contracts. However, the engineer did not prove details of the conversations alleged to comprise a valid verbal contract under which the architectural company agreed to share profits with the engineer. Therefore, the higher court refused to hold in favor of the engineer, saying:

"We are of the opinion that because of their incompleteness, indefiniteness, and uncertainty as to essential terms, the conversations testified to were insufficient to constitute a valid contract."

And again see Anderson v. Backlund, 159 Minn. 423. This court said:

"Contracts must be certain in terms, and not so indefinite and illusory as to make it impossible to say just what is promised. The proof in this respect is insufficient."

According to a recent higher court any employe whose duties are the furtherance of interstate or foreign commerce must apply for compensation under

the Federal Employers' Liability Act, instead of under the State Workmen's Compensation Act.

For example, in Wills v. Terminal R Association of St. Louis, 205 S. W. (2d) 942, it was shown that an employe was employed as a sheet metal worker. On the day he received his injury, he was helping to install a pipe ventilator through the roof of a building used for forging iron parts which were used in the repair of boxcars moving in interstate commerce. It was a health measure, and was installed for the convenience and comfort of the blacksmiths working inside the shop. The employe fell from the roof of the building to the concrete platform in front of the shop, and sustained severe injuries.

The lower court held that the employe could recover $2,000 compensation under the State Workmen's Compensation Act. The higher court reversed this decision saying that the employe must apply for compensation under the Federal Employers' Liability Act. The court said:

"It might be that the workmen could work in a shop inadequately ventilated and at the expense of their health and comfort. But, this would, beyond doubt, impair their efficiency, and affect adversely the movement of commerce. Anything done to alleviate this condition would undoubtedly be in furtherance of interstate commerce."

Also, see Zimmermann v. Scandrett, 57 F. Supp. 799. Here an employe was killed while engaged in repairing a door in a roundhouse, which was used for the housing and repairing of locomotives utilized in interstate commerce as well as intrastate commerce. The higher court held that he could receive compensation under the Federal Employers' Liability Act.

Error in Tax Payment

According to a recent higher court a heating company should immediately notify a state, county, or city that it paid taxes by mistake. Then it may sue to collect the overcharge at any time in the future.

For illustration, in Longacre Park Heating Co. v. Delaware County, 50 Atl. (2d) 706, the Longacre Park Heating Co. sued Delaware County to recover realty taxes erroneously paid to the county for the years 1934, 1935, and 1936. The heating company notified the county officials that these taxes were paid erroneously. The county refused to make the refund. The heating company sued the county eleven years later.

The higher court held in favor of the heating company, saying:

"True, the suit here was brought eleven years after payment, and eight years after discovery of the error. But what of that? Even eleven years is not an unreasonable period within which to bring suit dealing with a subject matter of which the county, throughout the whole period, had a complete, accurate and permanent public record."

Not Partial Liquidation

It is well known that a stockholder in a corporation need not pay Federal income tax on money paid or distributed to him in full or partial liquidation of the corporation. However, a new higher court decision holds that money received by a stockholder from reduction of capital in a corporation is taxable.

For example, in Sheehan v. Dana, 163 Fed. (2d) 316, it was disclosed that one Dana invested in stock in the Charter Oak Stove and Range Co. The testimony showed that the company distributed stock dividend from its surplus from 1914 to 1934, but the years 1921 and 1931-1934, inclusive, were loss years, and as of September 1, 1934, the books of the company showed a deficit of $23,558.53. The business of the company had steadily declined for several years, and its capital requirements were greatly reduced. The company reduced the par value of its stock and transferred the amount resulting from the reduction to a surplus account and the business continued as before.

In subsequent litigation, the higher court held that these distributions from the surplus thus created to Dana in subsequent years was taxable as ordinary "dividends", and did not constitute "distributions in partial liquidation".

New Company Taxed

Considerable discussion has arisen from time to time over the legal question: If a company begins operation of a new business how can the Appraisor or Assessor arrive at the value of the company's property?

For example, in Natatorium Co. v. Board of Commissioners of Ada County, 174 Pac. (2d) 936, it was shown that the Natatorium Co. for many years has been engaged in the business of selling natural hot water for heating residences in Boise, Idaho. Apparently it is the only concern known to be engaged in the business. The legal question was presented the court, as follows: How can the assessor arrive at the value of the company's property for taxation purposes?

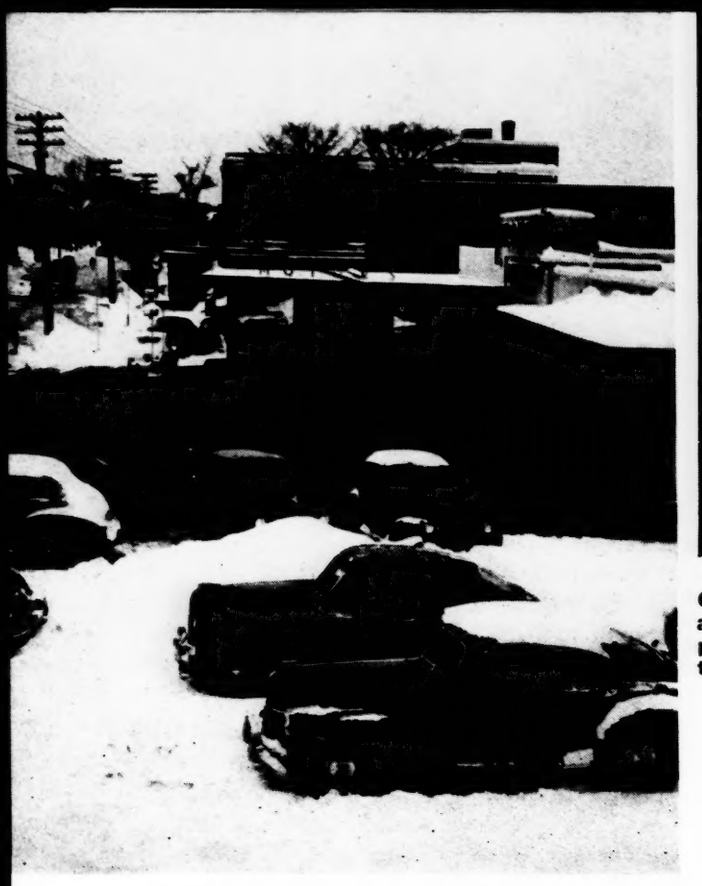
This court held that in determining the value of the company's property for purpose of taxation, the assessor must determine either the value at which the property would be taken in payment of a just debt due from a solvent debtor, or the amount the property would sell for at a voluntary sale made in ordinary course of business, taking into consideration the company's earning powers.

What is an Accident

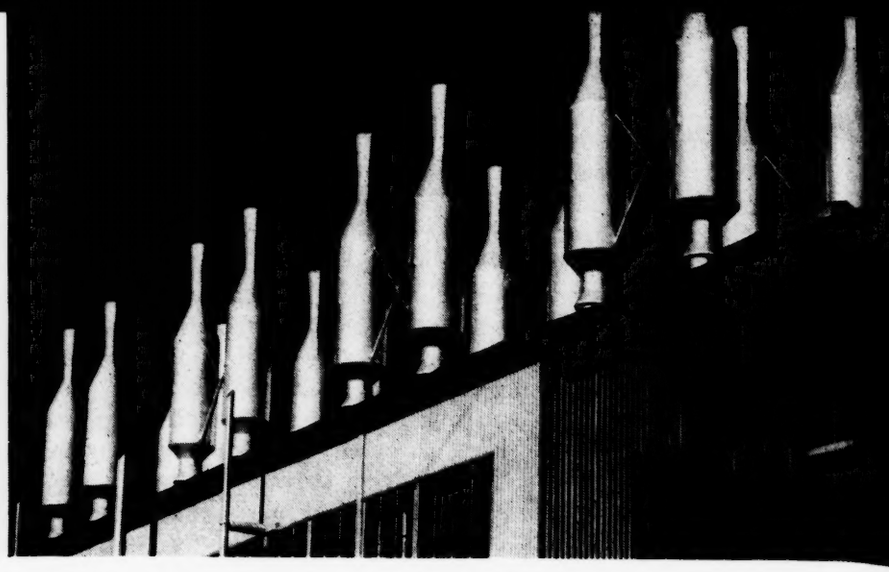
Considerable discussion has arisen from time to time over the legal question: What is an accident which entitles an employe to compensation under the State Workmen's Compensation Act for an accidental injury?

For instance, in Rivers v. American Radiator & Standard Sanitary Corp., 48 Atl. (2d) 311, it was shown that an employe was scraping rust from the side of a container when he collapsed. He died immediately. The higher court awarded compensation to his dependents holding that the death arose from an accident. The court said:

"When the contributory strain arises out of and in the course of the employment the accident likewise so arises."



No shovels, plows, or chemicals were needed to keep the driveway of Swearingen Motors at Portland, Maine, free from ice and snow last winter. Hot water forced through pipe coils buried in 6,600 sq ft of driveway melted away record snow storms and kept ice from forming. A separate radiant heating system with floor coils was used in the showroom and garage.



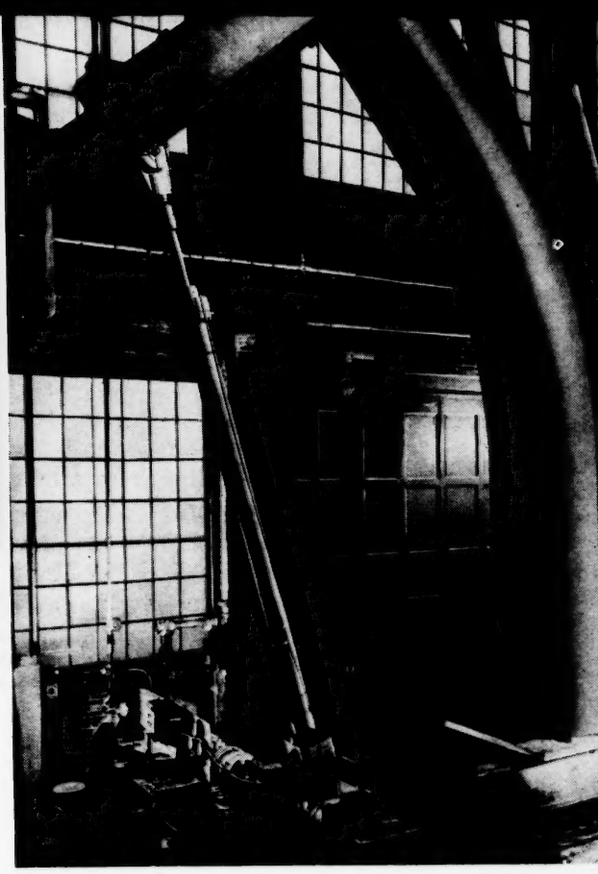
Compressor exhaust mufflers on the roof of a Shell Oil Co. gasoline plant at Wasson, Texas. Purpose of the plant is to process petroleum gas produced naturally along with crude oil. The gas is wrung like a sponge to recover valuable liquid gasoline components. What is left, the dry gas, is then sold for cooking and heating.

Picture

(Left)—The 18-story Irwin-Keasler Building, Dallas, Texas, has been entirely air conditioned in thirty days—only a fraction of the time usually required for such jobs. Co-owner, T. K. Irwin gives credit for record speed to labor-contractor cooperation sparked by the personality of general superintendent G. L. Howell, former Seabee, who supervised the undertaking. Seventy-seven Chrysler Airtemp packaged air conditioning units were used. These were placed in batteries of 12 or 13 on every third floor. Each battery serves the floor on which it stands, the floor above, and the floor below.

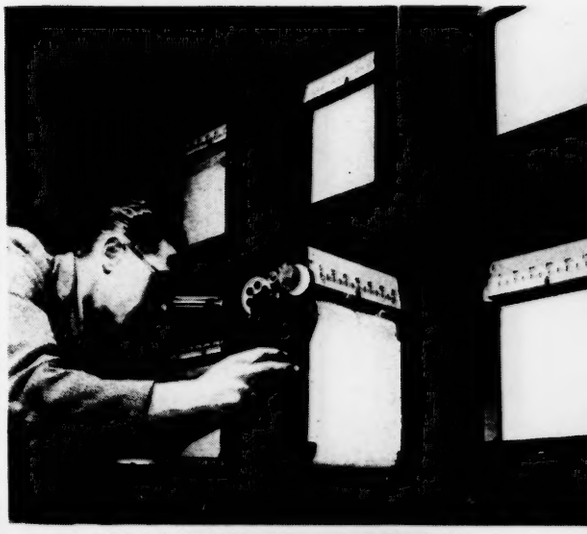
(Below)—An inspection trip to the I-B-R Research Home was one of the features of the second short course in hot water and steam heating systems at the University of Illinois, June 15 to 17. Shown below is a group of students about to enter the home. The research work carried on in the home for the improvement of hot water and steam heating systems was explained to the students by guides.

Employees of Western Engineering & Manufacturing Co., Los Angeles, observed the 28th anniversary of the founding of the business recently. C. H. Forbes, president and founder, and C. H. Kastner, general manager, posed with a group of shop employees for this photograph. In the foreground is a partial day's production of rotary turbine ventilators.



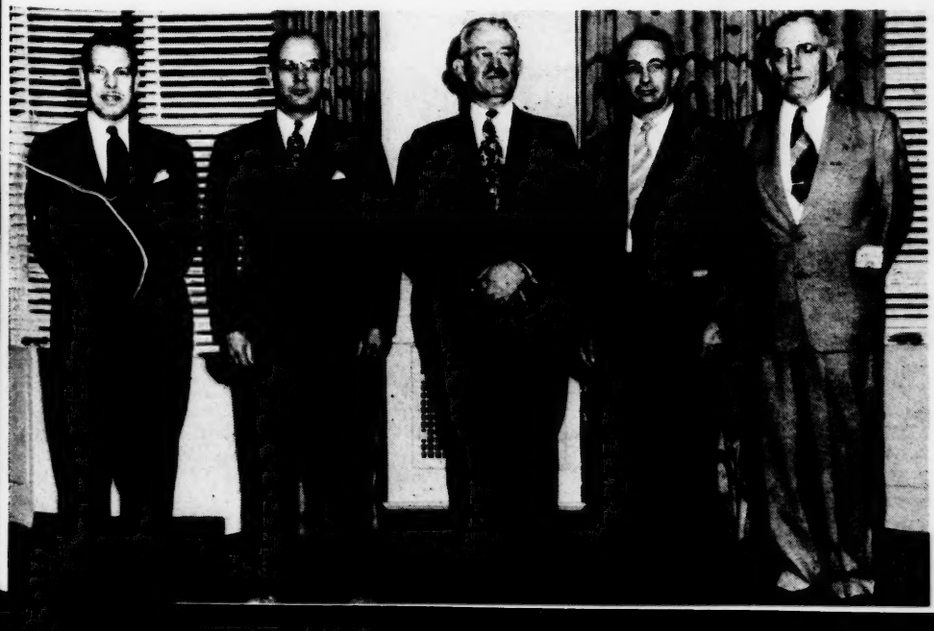
A powerful hydraulic machine for bending pipe as large as 8 ft in diameter is shown at work on a 50-in. pipe—largest one-piece bend ever made—at the Jersey City works of the M. W. Kellogg Co., petroleum and chemical engineers. Bends are made with uniform contour and cross section, under hydraulic loading at 1450F to a contour accuracy of .05 degrees.

Paragraphs



(Right)—In twenty-eight houses of similar design, British engineers are testing insulation and heating plant efficiencies in a large scale research project involving 92 different heating appliances and systems. All houses are fitted with recording instruments which register at a central control room. Group of pictures at right shows (top) room temperature recorders, a eupatheoscope (lower left) which tells how man would feel under the same conditions existing in a room, and (lower right) an air temperature survey to find cold spots in a room. British official photo.

(Below)—Officers elected at the St. Louis meeting of the National District Heating Association are, left to right, A. T. Veness, third vice-president; G. H. Tuttle, second vice-president; H. L. Martin, president; D. W. Loucks, first vice-president; and J. F. Collins, Jr., secretary-treasurer.



Graphical Determination of Heat Transfer Film Coefficient for Carbon Dioxide Vapor

B. F. RABER* and F. W. HUTCHINSON**

THIS sixteenth article[1] in the series on refrigerants presents the film coefficients of heat transfer for carbon dioxide vapor when being superheated or desuperheated, but not during the process of condensation. The two graphical solutions, Fig. 31 and 32, are similar in form and in use to those which have been presented for other refrigerant vapors. Limitations in use of the two graphs occur under conditions for which the Reynolds number is less than 100; for Fig. 31 the minimum permissible weight rate is approximately 0.5 corresponding to a gage pressure of the vapor of 0 lb per sq in. For 100 lb per sq in. gage the weight rate must exceed 1.75 and for 200 lb per sq in. gage it must be greater than 2.75 lb per (sec) (sq ft).

Use of the graphs will be demonstrated by means of an example: Carbon dioxide vapor is being cooled, at a mean temperature of 50F, within a very thin-walled tube for which both inside diameter and outside diameter can be approximately taken as 0.5 in. The flow rate of the desuperheating vapor is 32 lb per (sec) (sq ft) of tube cross-section. Cooling effect is provided by a stream of superheating carbon dioxide vapor, at 0F mean temperature, which flows normally across the transfer tube at a flow rate of 7 lb per (sec) (sq ft). Determine the inside and outside film coefficients of convective transfer and evaluate the overall coefficient of heat transfer from vapor-to-vapor.

Solution: The inside film coefficient is determined from Fig. 31 by entering the bottom weight velocity scale at 32, rising vertically to intersection with the horizontal for a ½ in. pipe, rising to the left in the direction of the radial directrix lines until intersection occurs with the base scale for the film coefficient. From this intersection rise vertically (see dashed example line) to intersect the horizontal marked 0F and from this point drop down and to the right in the direction of the directrix lines to read the answer as 52 Btu per (hr) (sq ft) of inside pipe surface per 1F temperature drop across the inside film. Similarly the outside film coefficient is determined from Fig. 32 by entering the bottom of the graph at a weight velocity of 7 lb per (sec) (sq ft), rising to the ½-in. horizontal, following the directrix to the base scale, rising to the 50F horizontal and following the directrix back down to intersect the base scale at an inside film coefficient of 26 Btu per (hr) (sq ft) of outside pipe surface per 1F temperature difference across the outside vapor film.

Assuming that the thermal resistance of the tube wall is negligible and that the area difference between inside and outside tube surfaces is also negligible, the overall coefficient of heat transfer for this system will be,

$$U = \frac{1}{\frac{1}{h_i} + \frac{1}{h_o}} = \frac{1}{\frac{1}{52.0} + \frac{1}{26.0}}$$

$$= 1/(.192 + .384) = 1/.576 = 17.3$$

Btu per (hr) (sq ft) (F).

Since the temperature difference between the two vapor streams is 50 — 0 = 50F it follows that the rate of heat transfer per square foot of pipe surface is $50 \times 17.3 = 865$ Btu per hr.

The above example assumed a thin-walled tube. If the tube were of normal wall thickness corrections would have to be made both for the thermal resistance of the tube wall and, of greater practical importance in most cases, for the difference between inside and outside surface areas. Correction for wall resistance has been discussed in previous articles and tables have been given for direct evaluation of the resistance for most types of alloy tubes commonly used in heat transfer.

Correction for surface area is a simple matter of diameter ratios. Thus if the inside surface area of the tube is used as a basis of evaluating the overall coefficient, the inside film coefficient read from the proper graph would be used directly in the equation for U, but the graph value of the outside film coefficient would be corrected by use of a multiplying factor equal to the ratio of outside-to-inside pipe diameter; the equation for the overall coefficient of heat transfer, exclusive of pipe wall resistance, is then,

$$U_i = \frac{1}{\frac{1}{h_i} + \frac{1}{h_o(d_o/d_i)}}$$

for use in the equation,

$$q = U_i A_i (t_h - t_c) \text{ Btu per hr}$$

where the subscript i refers to the inside surface of the pipe.

In many types of problems the heat transfer rate is required in terms of a lineal foot of pipe. This can be determined by evaluating an overall coefficient of heat transfer, U_1, from the equation,

$$U_1 = \frac{\pi}{\frac{1}{h_i D_i} + \frac{1}{h_o D_o}}$$

for use in the equation,

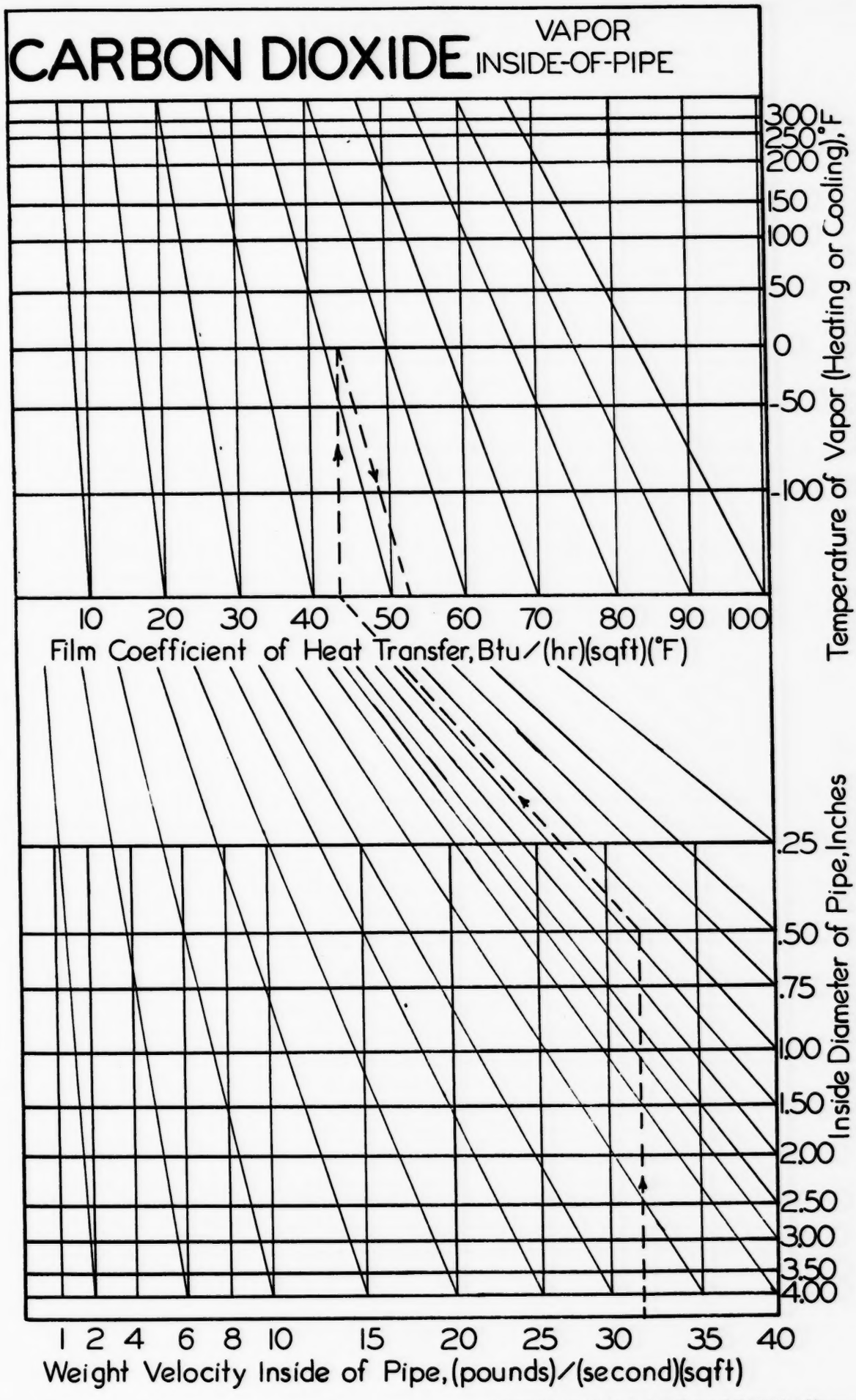
$$q = U_1 L (t_h - t_c) \text{ Btu per hr}$$

where L is the length of tube in feet and D is the tube diameter, also in feet.

*Professor of Mechanical Engineering, University of California, Berkeley.

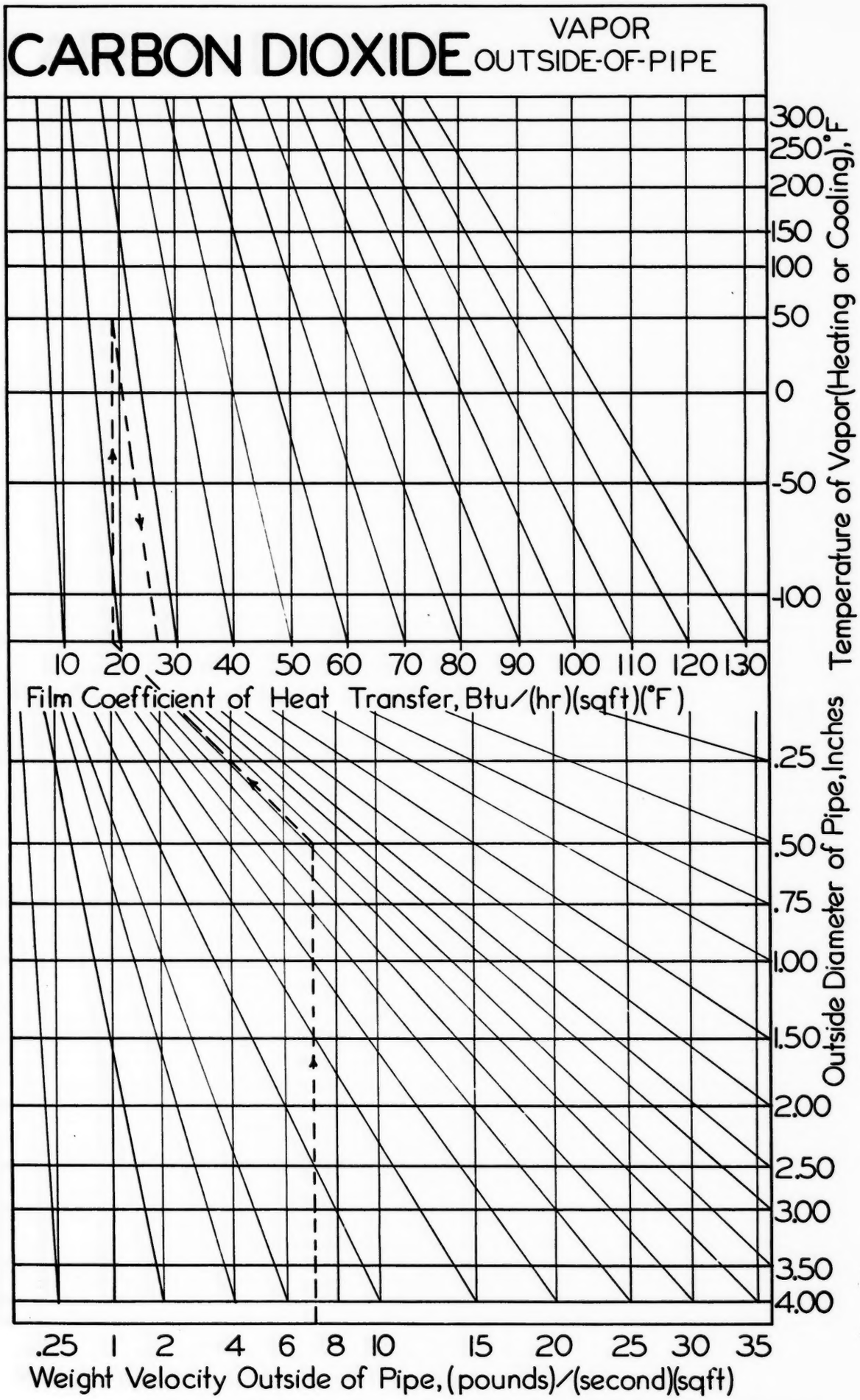
**Professor of Mechanical Engineering, University of California, and Consulting Professor of Mechanical Engineering, Purdue University.

[1]The first article of this series appeared in HEATING AND VENTILATING, December, 1944.



Copyright, 1948, by B. F. Raber and F. W. Hutchinson

Fig. 31. Film coefficient for carbon dioxide vapor flowing inside a pipe.



Copyright, 1948, by B. F. Raber and F. W. Hutchinson

Fig. 32. Film coefficient for carbon dioxide vapor flowing outside a pipe.

THE SALES ENGINEER

Taking a Look at Yourself

BERNARD LESTER
Sales Engineering Consultant

WHY is it a sales engineer may know his apparatus, be able to engineer its use,—yes, even be a clever negotiator—and yet fail to do a successful job selling? Usually it is due to the fact that his personal traits and character do not strike a favorable note with those upon whom he calls. Often the prospect cannot define what he lacks. The fact is, that he fails to "click" with the very man who can give him an order. He is just not liked.

Every sales engineer can go far in training himself, if he will only study his make-up, see himself in action as others see him, and conscientiously conquer weaknesses step by step.

A salesman is said to be an extrovert. His mind is centered upon people and he carefully analyzes them. Why should he not analyze his own attributes and actions? Personality can be developed. Bad habits can be corrected and be replaced with good ones, so that subconsciously the individual becomes pleasing to others.

Where the radio announcer depends upon vocal expression, and the model on her form, the sales engineer has a particularly broad field in which to put his personal attributes to work. Since he is more than an actor, and actually must live the part he plays, there is one attribute which stands out above all the rest. It is *sincerity*. Sincerity goes far beyond pose, gesture or canned talk. It is the foundation for genuine enthusiasm.

It may be helpful to cite some of the personal factors that affect sales success. These, of course, are based upon what the average individual likes in another. They apply particularly to meeting people in a business way and talking to them.

Personal appearance is always important. Cleanliness and neatness are always desirable. Extremes in attire should be avoided. Impressions created by odd and gawdy dress may attract attention, but often unfavorably.

A pleasant manner is catching. I have repeatedly seen sales engineers maintain a pleasant manner under strained and uncomfortable circumstances, only to see in time, the one he interviews finally assume a similar attitude. A touch of humor at the right moment, or a homely smile, can sweeten a serious topic and give it color.

Most of us have some distinct mannerisms. Sometimes they detract and even annoy. Others are natural and harmless—they serve to genuinely express our personality. It detracts from an interview to fail to look the person in the face. It is pleasing to hear one speak clearly, so that understanding is easy. The voice that is neither too low nor too loud serves as the best vehicle for expression. Slouching in the chair may indicate lethargy. A stiff and awkward position may show strain and characterize undue formality. Fumbling with objects or continually stroking the hands, face or head may distract, and display fear or unease. Undesirable mannerisms such as these can be discarded, so that all the faculties of the sales engineer may be devoted to getting his story across in a pleasing and convincing way.

Many a sales engineer is in a rush to be able to call his prospect by his first name. Some people you meet in business like this. Others may take offense. Circumstances govern cases, but the safest and surest way is to proceed slowly in expressions of familiarity. Nothing is lost by doing so. Much may be gained.

Remembering prospects' names is very important. It pays to get the name right and properly pronounced at the start. Most people don't object to having their name repeated during the conversation,—in fact they like it. Introducing the name now and then, in conversation, helps to fix it in the sales engineer's mind. "Name-memory" to most of us is much more difficult than "face-memory." It can be cultivated by always associating the name at the start with some object, incident or person familiar to us.

Some of the most successful sales engineers I have met, are inclined to do very little talking, except when they have the floor, so to speak, and engage in an explanation. You pay a compliment to an individual when you listen to his story. Most of all, listening gives the sales engineer an opportunity to get facts, not only about the subject in hand, but also about the person who does the talking. As the time elapses he can formulate his next move. An interested listener, too, sometimes gets credit for knowing more than he actually does.

Most people object to being interrupted. The anxious and inexperienced sales engineer is quite apt to break in to a prospect's conversation. When the prospect makes a serious complaint and is exercised and excited about it, it is well to let him complete his story. He is usually much more amenable to reason after he has gotten the subject "off his chest."

These are some of the points to look for in examining the personal characteristics of the salesman in his contact with customers. They all contribute to his acceptability. They all revolve around the main characteristics of sincerity, consideration for others and a genuine desire to serve.

Experience is my Classroom

By T. W. REYNOLDS

NEVER TROUBLE TROUBLE

The more engineering you do the more experience you will gain, also the more troubles you will have. Whenever the writer got into trouble he used to call on an engineering friend for assistance, a Mr. White, no longer with us. When asked how to get out of trouble, Mr. White would say. "I don't know, I always kept away from trouble," and then as the thought had time to gel in your mind, would add, "But let's see how I would get out of trouble if I did get into it." He was a great help, but he never forgot to first drive home the point that the best corrective was to do things carefully and thoughtfully so that no correction was required.

COLORFUL ITEMS

The Beech-Nut Packing Co., Canajoharie, N. Y., has all the answers. The roof of each of their buildings is of black tar for good heat absorption during the winter, but absorption of heat is prevented in the summer by painting over the tar with a short lived water emulsion white paint. Arrival of cold weather finds the paint all weathered off and the cycle is repeated. Color is a wonderful thing. Given the right color, we can make a room feel warmer or cooler as desired. We can also reduce the amount of lighting required and therefore the heat gain.

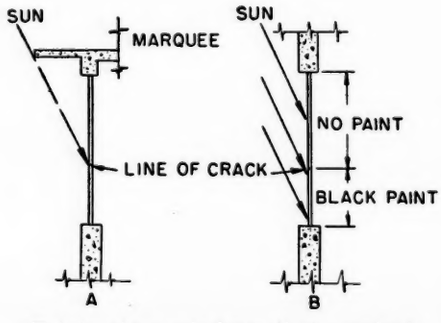
ABOUT CRACKS

A good part of the first and operating cost of our heating and air conditioning plants is chargeable to the glass in our windows. Recognizing this fact we have struggled and have finally overcome the handicap to a considerable extent by making glass more heat resistant. Having accomplished this, we start in to use more glass than formerly and wind up back where we started in so far as the effect on the mechanical plant goes.

New things bring new troubles, at least for a time. Triple glass sometimes cracks, at least 10% of the windows on one store installation have. The cracks are all practically horizontal and about 28 in. up, see *A*, being mainly confined to southerly windows. As the sun leaves, the glass takes the full effect of outdoor air which may have a temperature of —30F. Due to a marquee, the sun is confined to the lower part of the glass, the line of division between sun and shade following approximately the crack line.

Everything seems to point to the combination of sun, a marquee and a cold climate, just as windows painted partly in black have cracked at the line of division between paint and no-paint areas as at *B*. Black is also a good heat absorber. On the other hand, while some of the windows cracked with building still under construction, others cracked much later. Furthermore, one or two windows cracked on the easterly side. Then too, the sash is of metal and perhaps is too rigid for a cold climate. Further investigation also discloses that the same glass as used in a residence in the same locality also cracked. In this case there is no marquee and the crack is vertical rather than horizontal.

Apparently there is much to be learned as to conditions under which glass will crack. The large glass window at a rotisserie in the World's Fair at New York cracked from the heat of the fire. On a few occasions large windows in banks have cracked when the windows are over large radiators with steam pressures raised somewhat to force circulation.



Triple glass windows that cracked.

Note: Mr. Reynolds is Chief, Air Conditioning Division, Abbott, Merkt & Co., Engineers, New York.

DIPLOMATIC SWEAT SHOP

There was an even dozen of us, all engineers working for a well known consulting engineer. We were mostly young, World War I time, but not such bad fellows all considering. Illustrative of the point, the boss's most important client came in one day when we had not hardly scratched the surface on his job. Becoming excited he shouted around and accused the boss of putting on an act, betting him good money that we would never be finished in a month as promised. The boss took it all quietly and just said, "The boys have never failed me."

Well, we all buckled down. We did not like this architect, his manner and the invasion of our sanctorum, nor did we like his abuse of our boss. So we were out to win the bet and show the architect up. We did just that. We won with hands down, then later fell to thinking, "Could it be possible?" Again looking backward, the writer thinks it was possible. The boss was such a clever boss and together with the architect evidently put on a very good act for their mutual benefit in getting the job done in a hurry.

PERSPIRATION

Some years back the garment center was a place where the bosses made the poor unorganized workers sweat to produce their utmost, hence these places, hot or cold, became known as sweat shops. Such wording by the writer at the dinner table brought a quick contradiction from his oldest daughter. She had been a model and sometimes visited those places. The so-called workers made $150 per week, she explained, and worked in nice air conditioned shops, so how could they sweat.

There was further objection to the use of the word "sweat" as a sort of unrefined perspiration. "Why", she complained, "do they always speak of the rich as perspiring while the poor man just sweats?" The writer could only say that perspiration is discomfort whereas sweat implies toil.

ALL IN A DAY'S WORK

Out on the job you get a lot of complaints. You also get a lot of laughs. The layman certainly has some misconceptions about air conditioning. The cooling water as it leaves the condenser of a certain unit is too hot, says one complainant, which proves our air conditioning is not good. Another fellow emerges from the fur vault. He has a fur piece in his hands with chrome on it as trim. Naturally, at the low dew point necessarily carried, the metal would be the first to collect moisture, so he says the humidity is too high. You ask him how much humidity he wants and he says "Oh, just give me half as much."

DUTCH PRACTICE

In the old Dutch farm house door was a hole not big enough for a dog, but for a cat. This door was said to be there for the purpose of letting a spirit out, and spirits did often take the form of a cat, so it has been said. The writer often wondered about the need for this hole, since it would seem that the spirit could go out by whatever way he came in, and if no hole were provided for exit, how the heck could he get in?

In questioning one old Dutch farmer about this, it was learned from his vague remarks that these openings were really for make-up air to the fireplace. Fireplaces were then very large and there was more than one, so quite some air would be required. It was a crude form of heating, in any event, since the hotter the fire, the greater the amount of make-up air required, therefore the colder the place became because of drafts.

In spite of all this, they did have radiant heating by way of the open fire and the great panel of hot masonry surrounding it. The high bench at the fireplace prevented many of the rays from escaping, acted in turn as a radiator, and kept the cold drafts from your back.

WEIGHTY THOUGHTS

Until the war came along, little thought had been given to the weight of each material comprising a heating system and just which type of heating system used the least critical materials. Such thought as was finally given was often confused, for it compared materials on the basis of weight without considering the relative merits of wood versus metal, copper versus steel, or steel versus cast iron. Things like concrete were considered of no importance, yet labor, handling, transportation, bulk and availability of fuel, railroad cars and locomotives all entered into the picture, while non-critical things required critical things to make or house them.

Although much importance of these factors has gone with the war, they will become of some importance as time goes on. Whoever develops a light weight heating system, either due to light weight materials or compactness of the system, will have something to offer. Less weight and bulk saves on handling, transportation and size of warehouses. In the structure there will be savings such as weight and in requirements for floor and overhead space. The more simple a heating system is made, the cheaper and quicker it can be erected or altered. Chases, furring, pipe shafts, holes left in beams, forms in concrete, sleeves and plates all take time, erection cost, increasing engineering costs, and delay in the planning stage. Due to unforseen events many holes have to be drilled in beams in the field and many a hole is laboriously knocked through concrete and then patched up. Many a heating system would not compare so favorably as to type or kind of system if the attendant costs to a structure for headroom and other items were included in the heating contract.

In the comparisons cited, convector systems give the least weight of metal due partly to the use of wood cabinets, but wood finally became more critical than steel. Radiator systems weighed the most, but cast iron was not as critical as steel. Fan furnace systems compared most favorably with the unit heater system, even though reinforcing steel for a time was critical, for the unit heater system used steel plate and tubing for boilers and copper for motors, controls, switches, wiring, valves and trap parts. Fan furnace systems could have been made with steel furnaces, while the use of asbestos ducts would have eliminated the need for reinforcing steel.

IT LOOKED BAD FOR THE MOMENT

A worried fellow complains of the lack of air movement in his department which he can prove, he says, by the ceiling outlets. One of these discharges no air whatsoever, while another one even sucks in the air. You tag along to look the situation over and find he is correct in his statements.

One outlet is a dummy put in to preserve the normal ceiling pattern of the outlets at a point where air is not wanted and the other outlet is used for exhaust at a point where an exhaust register would not have looked so good. You tell him all this, but he does not believe it until you take the dummy down and show him that it is not connected to anything.

Case 1 — Heating an Office Space — Boiler Room Equipment Not Included

System	Total Weight, Lb	Lb per Sq Ft EDR	Major Weight In Lb	
			Radiation	Pipe and Fittings
A—Convectors (100 lb).....	2,716	1.9	728	1,643
B—Convector (L.P.)	4,627	3.2	1,653	2,755
C—Pipe Coils (100 lb).....	6,643	4.6	4,642	1,656
D—Rads. C. I. (L P.).....	9,501	6.6	6,489	2,793

Space, 140 ft x 28 ft x 12 ft high with 8 in. brick wall, heated from 0 to 70F with 1,444 sq ft EDR. Systems *B* and *D* are low pressure steam at 215F. Systems *A* and *B* are with wood cabinets. Systems *A* and *C* are high pressure steam at 100 lbs.

Case 2 — Heating an Industrial Building — Boiler Room Equipment Included

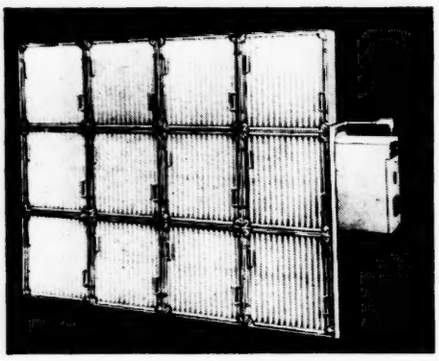
System	Total Wt. Lb	Lb per Sq Ft EDR	Major Weights in Pounds			Pipe and Fittings	Rads.	Breeching
			Boiler	Stoker	Unit Heaters and/or Motors			
E—Unit Heater (20 lb)	53,189	2.9	18,400	9,500	6,126	14,400	.....	1,760
F—Fan Furnace	75,648	4.1	31,533	11,000	875	.....	.....	2,400
G—Rads. C. I. (5 lb)	168,171	9.1	18,400	9,500	.....	29,685	104,457	1,760

Size, 324 ft x 142 ft x 25 ft high, heating 18,442 sq ft. EDR, hot water supply 758 sq ft EDR. System *E*, unit heaters at 20 lb steam pressure; system *G*, cast iron radiators at 5 lb pressure; system *F*, fan furnace (cast iron) and concrete air ducts outside of furnace room, including 22,100 lb reinforcing steel in floor slab over ducts (hot water supply by separate heater weighing 2,150 lb).

NEWS OF EQUIPMENT AND MATERIALS

Air Filter

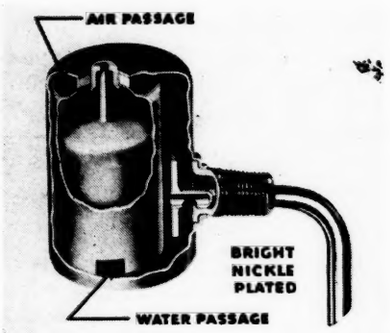
NAME—Electro-PL unit type electric air filter.
PURPOSE—Filtration of air through electronic means for such installation requiring a cleaning efficiency



between the mechanized filter and the electronic precipitation.
FEATURES—Filter is basically an electronic precipitator without an ionizing unit and contains a collector element of electrostatically charged paper. This paper is a laminated cellulose product which consists of several plies of porous, tissue-like sheets. When an electronic charge is applied to this paper, the plies tend to separate and each individual fibre becomes a collecting electrode to attract and hold dust and smoke particles. Unit will continue to function as an air filter even though it is deenergized so that operation can be regulated to suit dust conditions. When full dust load has accumulated on the filter paper, Airmat paper can be replaced.
LITERATURE AVAILABLE—Bulletin 257.
MADE BY—*American Air Filter Co., Inc., 215 Central Ave., Louisville 8, Ky.* **260**

Radiator Valve

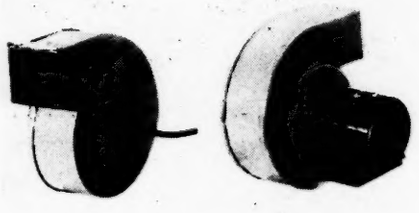
NAME—Dri-vent radiator valve.
PURPOSE—For controlling the venting of air in radiators.
FEATURES — A large separating chamber is provided to take air out of a mixture of air and water in the valve. Air is diverted to a separate chamber and then to the atmosphere. Only water is permitted to reach the reservoir under the float so that the float can rise and regulate the flow of air through the air vent. A water column action automatically measures the rate of air discharge and raises the float to throttle the valve when the rate of air flow is excessive. Unit consists of two shells with a separating space between the two. Connection from radiator to unit is raised above the bottom of the valve body to provide for a water seal a the bottom of the separation between the two shells.
OPERATION—Air rises to the top of the outer shell, passes through the air passage and then to the inside of the inner shell. It is here that additional moisture is removed from the air and this moisture falls to the top of the float, and through



capillary action, to the reservoir in the bottom of the shell. Moisture-free air is vented to the atmosphere through the metered outlet.
MADE BY — *Frank D. Riggio Co., 38 Orient Way, Rutherford, New Jersey.* **261**

Centrifugal Fan

NAME—Type 5CB centrifugal fan.
PURPOSE—Small fans for cooling and ventilating applications.
FEATURES—Units may be produced



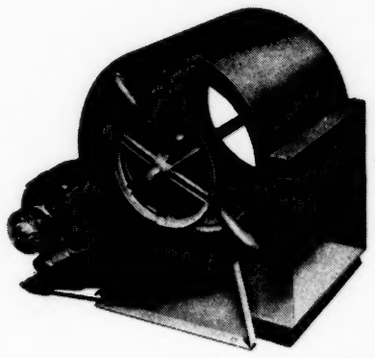
in single or double width types and can be supplied with a wide range of motor sizes and speeds. Brackets and mountings are supplied to meet any specific application. Fan has a wheel diameter of 5 in.
MADE BY—*Johnson Fan & Blower Corp., 1319 W. Lake St., Chicago 7, Ill.*.....**262**

Window Filter

NAME—Wind-O-Filter.
PURPOSE—Filtration of air.
FEATURES—Adhesive coated aluminum baffles are used. Movable extensions make it possible to affix in all standard size windows.
SIZES AND CAPACITIES — Three basic sizes, all 8 in. wide, are extendable from 20 to 26 in., 26 to 32 in., and from 32 to 38 in.
MADE BY—*The Research Products Corporation, Madison, Wis.*.....**263**

Blower

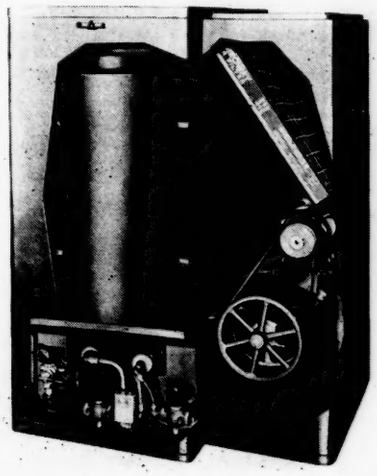
NAME—Viking W-110 blower assembly.
PURPOSE—Blower assembly for furnace manufacturers.
FEATURES—Assembly has been designed for furnaces used in the smaller homes, and is equipped with streamline bearings and oil



cups that hold a year's supply of lubricant. Assembly has standardized outlet dimension making the unit interchangeable with conventional blowers of similar size.
SIZES AND CAPACITIES—1000 cfm at ½ to ⅝ in. static pressure.
MADE BY—*Viking Air Conditioning Corp., 5600 Walworth Ave., Cleveland, Ohio.* **264**

Furnace

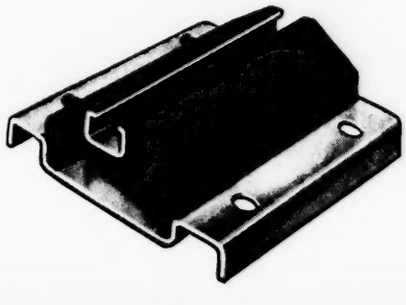
NAME—Superfex gas-burning furnace, Model 62.
PURPOSE — Space heating for the home.



FEATURES—A 3-stage burner is used —pilot, low and high fire, and a 2-speed blower. Low fire is used to maintain heat balance in average cold weather and high flame is placed in operation during severe weather. Blower is of the squirrel cage type, mounted on rubber bearings. Blower section may be located on either side of the furnace. Combustion chamber, radiator and casings are of sheet steel. All controls are assembled and wired at the factory. An automatic meter regulates water to the humidifier pan in proportion to air temperature.
SIZES AND CAPACITIES—80,000 Btu at bonnet.
MADE BY — *Perfection Stove Co., 7609 Platt Avenue, Cleveland 4, Ohio.* **265**

Vibration Control

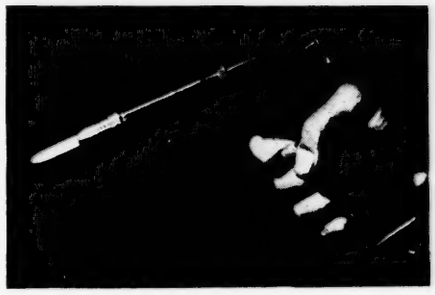
NAME—Chan-L-Mount.
PURPOSE—Packaged vibration control.



FEATURES—Mounting is 1½ in. high and is installed by sliding under the machine to be mounted. The bolt head is inserted in either end of the metal channel which holds it while the nut is tightened. A cushion of soft rubber prevents metal-to-metal bottoming, under occasional shock.
SIZES AND CAPACITIES — Made in range of sizes for small and medium weight machines.
LITERATURE AVAILABLE — Bulletin 300.
MADE BY—*Lord Manufacturing Co., Erie, Pa.* **266**

Acetylene Torch

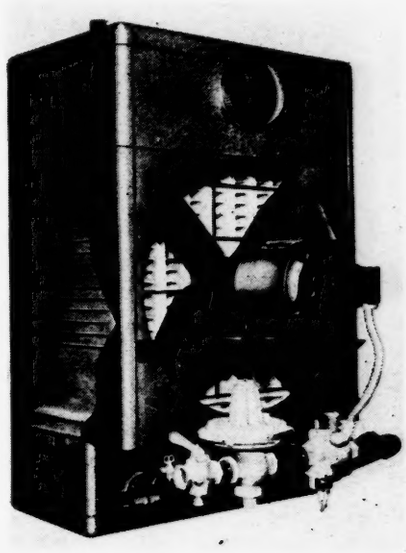
NAME—Century gas gun.
PURPOSE—To speed up soldering, brazing and lead burning.
FEATURES—Unit is designed to operate only with acetylene gas. It is ordinarily used with MC or B type acetylene tanks for soldering joints,



sweating in of copper fittings, light brazing or lead burning. The flame is never left burning when not in use and interchangeable combustion tubes, nozzles and extension tips provide a range of flame sizes for a great variety of jobs.
MADE BY—*Century Aircraft Co., 5601 West Century Blvd., Los Angeles 43, Calif.* **267**

Unit Heater

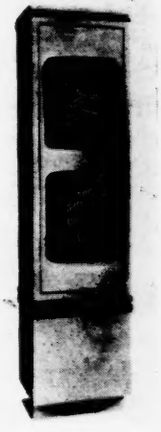
NAME—Pittsburgh gas unit heater, series C.
PURPOSE—Space heating using gas as fuel.
FEATURES—Extended heating surface fins on the heat exchanger are cast integral. A built-in draft hood is said to absorb all excessive chimney action. A safety pilot on heater automatically turns off the gas should the pilot light go out or if it burns too low to insure good ignition. Draft diverter gives protection against possible down drafts through the chimney. Unit is approved by the AGA.



MADE BY—*Automatic Gas Equipment Co., 301 Bruston Ave., Pittsburgh 21, Pa.* **268**

Air Conditioning Control

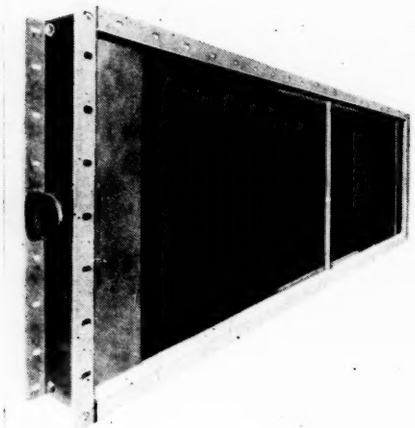
NAME—Foxboro packaged instrument control.
PURPOSE—To provide dry bulb and dewpoint temperature controls for air conditioning systems.



FEATURES — Steel doors at the back of the cabinet enables access to wiring. Indicator at top of cabinet provides dry bulb and dewpoint temperature readings. Key switch panel below connects the indicator with the multiple resistance bulb circuits for temperature measurement and Dewcel circuits for dewpoint measurement. Panel can handle 96 circuits or 48 circuits, each having two circuit connections, so that readings can be taken from various points.
MADE BY—*Foxboro Company, Foxboro, Mass.* **269**

Heating Coils

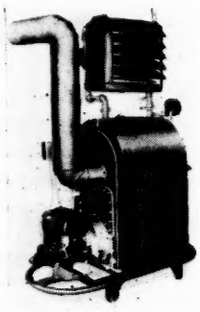
NAME—McQuay non-ferrous extended surface heating coils.
PURPOSE—Heat transfer.
FEATURES—Continuous plate type



aluminum ripple fins are used to provide extra heating surface. Corrugations also protect coil faces against lateral deformation. Eliptube headers are provided to reduce coil core strains during start-up period. Steam baffles provide for better steam distribution and intruded tube holes aid the Eliptube headers in compensating for start-up strains. There are six standard fin spacings—3, 4, 5, 6, 7, and 8 fins per in. Nineteen standard nominal tube lengths are available.
LITERATURE AVAILABLE — Catalog No. 300.
MADE BY—*McQuay, Inc., 1600 Broadway, N.E., Minneapolis 13, Minn.* **270**

Heat Generator

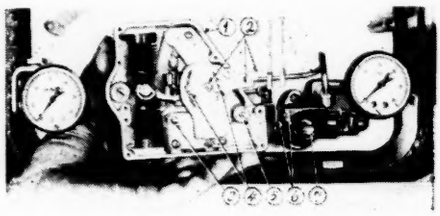
NAME—Eco-Temp heat generator-dispensor.
PURPOSE—For creating suitable temperature in the construction field for drying of concrete, plaster or paint.



FEATURES — To operate, it is necessary to provide an opening for a smoke pipe, a water hose and connection to a 110 volt, 60 cycle a-c outlet. Unit burns about 1.5 gal No. 2 fuel oil per hour. The fuel tank holds 30 gal. Mounted on rubber tired casters, it can be moved easily.
SIZES AND CAPACITIES—The stream type unit is capable of delivering 181,000 Btu per hr, while the hot water unit has a capacity of 113,000 Btu per hr.
MADE BY — *Arthur C. Baumann, 7011-21 Grays Ave., Philadelphia 42, Pa.* **271**

Mechanism Control

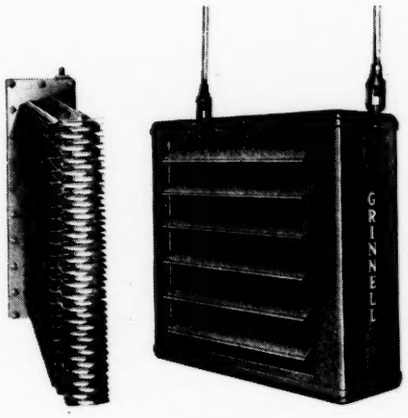
NAME—Fischer & Porter pneumatic control mechanism.
PURPOSE—Control for use with flow controlling instruments.
FEATURES—Entire assembly may be removed from control instrument for servicing by flicking the transfer valve to the service position, disconnecting an air line and removing four screws. Valve action



is readily reversible without altering link relationships. In photograph, (1) is the housing, (2) concentric input and index action which maintains fixed relationships throughout the entire range, (3) control point, (4) control assembly which can be removed without shutting down the system, (5) reset speed adjustment which is calibrated from 0.2 to 50 minutes, (6) transfer valve, and (7) throttling range adjustment.
LITERATURE AVAILABLE—Bulletin.
MADE BY—*Fischer & Porter Co., Dept. 17-N, Hatboro, Pa.* **272**

Unit Heater

NAME—Grinnell textile thermolier.
PURPOSE—Unit heater designed to meet atmospheric conditions in textile plants.
FEATURES — Conventional finned surfaces have been eliminated and replaced with heat transfer surfaces of smooth contour in order to eliminate possibility of lint and other dust from collecting on such surfaces. Cleaning can be accom-



plished by an electric hand blower or compressed air line. The high volume of air delivery provides a partial self-cleaning action.
SIZES AND CAPACITIES—One size unit is available with a rate of 113,700 Btu per hr when using steam at 2 lb pressure and with entering air at 60F.
MADE BY—*Grinnell Co., Inc., Providence, R. I.* **273**

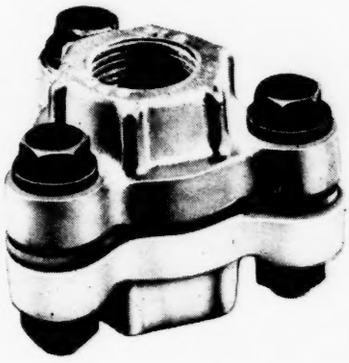
Wall Heater

NAME—Hollywall heater, Model 45.
PURPOSE—Space heating.
FEATURES—Upper louvers give a downward direction to the warm air flow, away from the wall, while the lower louvers direct heat to the floor. The face of the wall panel is said to remain safely cool. Heater

is installed entirely above the floor and all working parts are housed in an easily removed unit for quick service. Wall panels are designed to hide all working parts.
SIZES AND CAPACITIES—Unit which fits into standard 2 by 4 in. wall stud construction has a 45,000 Btu rating.
MADE BY—*Holly Manufacturing Co., 875 S. Arroyo Parkway, Pasadena 2, Calif.* **274**

Union

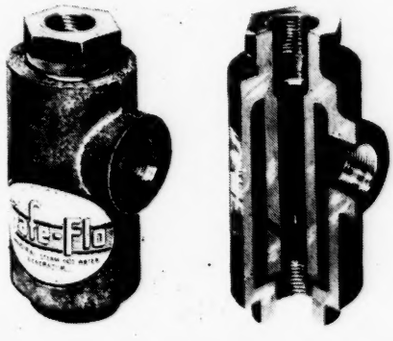
NAME—Hotstream dielectric union.
PURPOSE—Union designed to increase the life of plumbing systems by eliminating electrolytic corro-



sion where ferrous and non-ferrous metals are joined.
FEATURES—Union consists of two pipe flanges, one of iron and the other of bronze. Both parts are insulated from each other by a non-conductor gasket. The connecting bolts are insulated from the bronze section of the union by non-conductor bushings. In installing, the iron section is connected to the galvanized pipe fittings while the bronze section is joined to the copper tube fittings.
SIZES AND CAPACITIES—3/4 in. female I.P.S. Other sizes planned for future production.
MADE BY—*The Hotstream Heater Co., 2363 E. 69th St., Cleveland 4, Ohio.* **275**

Water Heater

NAME—Safe-Flo hot water generator.
PURPOSE—For generating hot water by mixing cold water with steam.



FEATURES—The cast iron cylinder is provided with inlets for cold water and for steam, and an outlet for the hot water. Inner construction consists of a series of orifices so that the entering steam heats the cold water without noise or back flash. Adjustment of two valves, one for cold water and one for steam, controls the temperature of the hot water.
SIZES AND CAPACITIES—Six sizes available for installation in pipe lines of 3/4, 1½, 2, 2½, and 3 in.
MADE BY—*Duffy Engineering Co., 20 S. E. Ninth Ave., Portland 14, Ore.* **276**

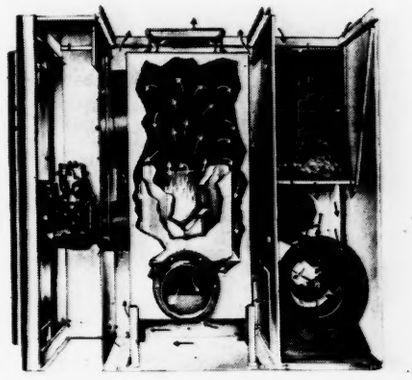
Furnace

NAME — Lennox vaporizing oil burning winter air conditioner.
PURPOSE—Space heating.
FEATURES—The air gate mechanism operates so that it is impossible to have high fire oil supply without adequate air for combustion, either at the start or completion of the high fire cycle. No air enters the pot during the pilot cycle, so that a small pilot is able to maintain adequate temperatures in the stainless steel pot. During the pilot cycle the oil supply line is cooled by the air which by-passes the pot. Unit is provided with blower, filters and automatic humidifier.

SIZES AND CAPACITIES—In floor cabinet or highboy models with capacities of 55,000 and 80,000 Btu per hr at the bonnet.
MADE BY—*The Lennox Furnace Co., Marshalltown, Ia.* **277**

Furnace

NAME—Williams Oil-O-Matic heating unit.
PURPOSE—Warm air space heating.
FEATURES—A light weight stainless steel combustion chamber is used which reaches incandenscence in a short time to speed heat transfer. A vertical counterflow heat exchanger is installed which places the smoke outlet at the bottom of the heat exchanger to force the hot gases to reverse their natural tend-



ency to rise. Makers claim that this achieves a high turbulence to provide maximum heat transfer in the low portion of the exchanger. Two 16 x 25 in. spun glass type filters are installed. Furnace has an automatic evaporative type humidifier.
SIZES AND CAPACITIES—Blower delivers 1,300 cfm at 3/8 in. static pressure. This is operated by a ¼ hp motor with built-in automatic thermal protector. Model 10A, illustrated, has a capacity of 100,000 Btu at the bonnet. A smaller unit, Model 70, has capacity of 70,000 Btu.
MADE BY — *Williams Oil-O-Matic Division, Eureka Williams Corp., Bloomington, Ill.* **278**

Refractories

NAME—3X Firecrete and 3X Blazecrete refractories.
PURPOSE—Refractories for service temperatures up to 3000 F.
FEATURES—The 3X Firecrete refractory is recommended by the manufacturer for casting or pouring special shapes such as door linings, furnace covers, etc. The other type was developed for pneumatic application in which material is shot in place by compressed air. Where gunning is not practicable, it can also be trowelled in place. Material hardens quickly and can be placed in service 24 hrs after installation.
MADE BY—*Johns-Manville, 22 E. 40 St., New York 16, N. Y.*.....**279**

Water Cooler

NAME—Temprite industrial type water cooler.

PURPOSE—To cool water and other fluids for industrial use.

FEATURES—Water coils are submerged in the liquid refrigerant and the heat of the water being used passes directly into the refrigerant. Water is cooled only as required, thereby eliminating unnecessary operation of the refrigeration unit. With the aid of an automatic control valve, the fluid temperature is said to remain constant whether 1 gal or full load is being imposed on the cooler. Cooler operates with refrigerant temperature only 4F lower than the desired exit water temperature, thereby permitting the use of a high-suction condensing unit.

SIZES AND CAPACITIES—Unit will deliver 1185 gal of water at 40F, assuming a 60F inlet temperature or 675 gal per hr of water, assuming an 80F inlet temperature. Cooler is 54 in. high and 14 in. in diameter.

MADE BY—*Temprite Products Corp., 47 Piquette Ave., Detroit 2, Mich.* **280**

Ashpit Viewer

NAME—Anthracite Institute ashpit viewer.

PURPOSE—To permit the operator of a hand-fired heating plant to view the condition of the fire bed.

FEATURES—Developed by institute engineers, a hermetically sealed mirror or prism is used, which extends through the ashpit door or base to reflect the image of the grate upward so that the operator can determine the condition of the fire. The operator is permitted to determine the fuel bed condition above the grate so that he can tell when to stop shaking the grate. The ashpit viewer, developed by the institute, can be installed in units produced by manufacturers of any hand-fired heating plant by slight changes in foundry pattern to provide a mounting for the device.

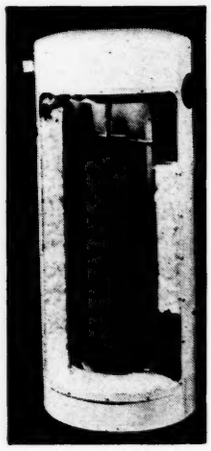
MADE BY—*Anthracite Institute, Wilkes-Barre, Pa.* **281**

Water Heater

NAME—EKM series, electric water heaters.

PURPOSE—Heating domestic water.

FEATURES—All models are provided with either one or two Radian-tube heating units similar to those installed on Frigidaire electric ranges. Each tank is protected from corrosion by a magnesium rod so that any electrolytic action will affect the rod instead of attacking the tank. Tank is backed by a ten-year replacement plan, so that in the event of tank failure during the second to fifth year, the entire heater will be replaced without cost; replacement will be at a special price if failure occurs during the sixth to tenth years, based on the number of years heater has been in use.



SIZES AND CAPACITIES—30, 32, 40, 52, 64, and 80 gal. units.

MADE BY—*Frigidaire Div., General Motors Corp., Dayton, Ohio*.....**282**

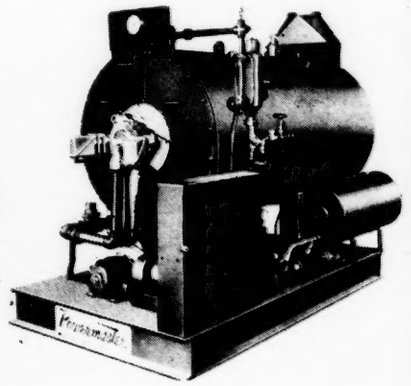
Steam Generator

NAME—Powermaster.

PURPOSE—Packaged steam generating unit.

FEATURES—Unit can burn light oil, heavy oil or gas and the changeover from one fuel to another is said to be a matter of a few minutes. A modulated control of flame volume is used to maintain constant steam pressure, as steam demand varies. A free swinging rear cover promises quick access to tubes for cleaning. Safety features for flame failure include an electronic operated fire-eye for use with oil, a flame rod for gas to automatically shut off the boiler in case of flame failure.

SIZES AND CAPACITIES—From 15 to 200 hp.



MADE BY—*Orr & Sembower, Inc., Reading, Pa.* **283**

Industrial Fan

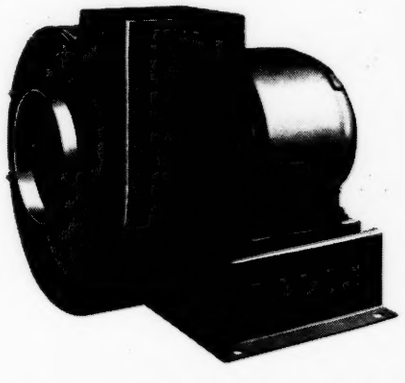
NAME—No. 10 G. I. industrial fan.

PURPOSE—Industrial ventilation.

FEATURES—Fan is provided with a manganese bronze wheel which has the advantage of being spark proof for use in explosive atmospheres. Wheel is also acid resistant. Two types of wheels are available, the L. S. wheel is used for a pulley drive and will operate at maximum rpm. The "wool type" wheel is furnished for speeds up to 3,450 rpm. Inlet has an area of 0.27 sq ft and outlet 0.22 sq ft. Arrangement of fan illustrated is suitable for temperatures of 180F.

LITERATURE AVAILABLE—Illustrated folder.

MADE BY—*The New York Blower Co., 32nd St., and Shields Avenue, Chicago 16, Ill.* **284**



Water Heater

NAME—Pennsylvania kitchen desk water heater.
PURPOSE—For heating domestic water.

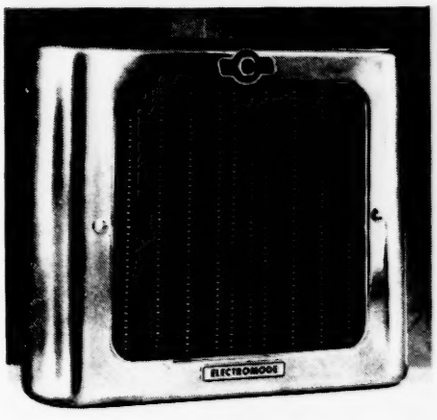
FEATURES—Unit has a built-in linoleum desk top. An electric arc-welded copper bearing steel tank is tested hydrostatically to 35 lb pressure. The cabinet has fiberglas insulation. Cold water diffusion baffles are included and the tank is provided with the Magnedur process for tank corrosion protection. It comes complete with desk lamp, clock and other desk features.
SIZES AND CAPACITIES—25 in. by 25 in. and 36 in. high. Available in both 30 and 50-gal models.
MADE BY—*Pennsylvania Range Boiler Co., 24th and Ellsworth Sts., Philadelphia 46, Pa.* **285**

Motor

NAME—Torq oil burner motor.
PURPOSE—Motor for use with oil burners designed to protect motor windings.
FEATURES—A snap action starting switch known as the Syncrosnap is used, which consists of a disc with integral fingers stamped as a single piece from spring metal. Action, which is instant and positive, occurs within the switch and the fingers. The switch is pre-set to act at maximum torque speed. Change-over from starting winding to running winding occurs with such rapidity it is claimed that there can be no more than normal heating of the starting winding due to load conditions. Rotors are of welded, copper bar construction and frames are of steel with die-cast aluminum end bells. Terminal box is cast in for easy wiring. Motor has sleeve bearings with extra capacity oil reservoir.
SIZES AND CAPACITIES—Motors are split phase, standard 1/6 and ¼ hp ratings and are provided in two standard flange mountings.
MADE BY—*Torq Electric Corporation, 1007 Interstate Street, Bedford, Ohio.* **286**

Room Heater

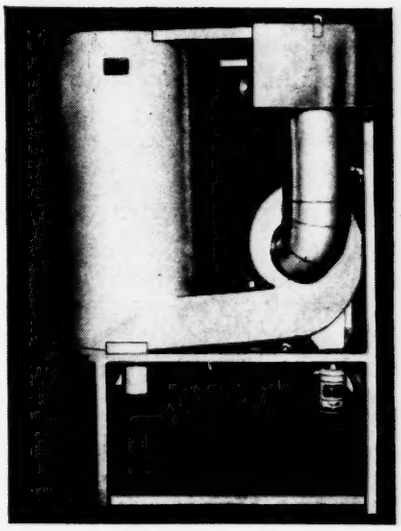
NAME — Electromode Bilt-in-Wall small room heater.
PURPOSE—For heating small size rooms.
FEATURES—Heat is generated by a cast-aluminum heating element which has no exposed wires or glowing coils. Unit is provided with thermal safety switch to prevent over-heating, and if desired, heat can be controlled by a thermostat. Rated at 1,320 watts, it is operated by a regular 110 volt a-c



house circuit. A built-in fan distributes 80 cfm of heated air.
MADE BY—*Electromode Corp., 45 Crouch St., Rochester 3, N. Y.*...**287**

Dust Separators

NAME—Niehaus dust separator.
PURPOSE — Air cleaning and dust separation.
FEATURES—Wet methods are used to remove dust and foreign particles from dust-laden air resulting from polishing, buffing, and grinding operations. The dust-laden air is mixed with fine particles of water which, by centrifugal action, wash out the entrained foreign material.



Clean air is discharged from the top of the machine into the shop. Unit contains its own blower and water recirculating system. Refuse is collected in a portable tank beneath the unit. Separator is delivered complete with motor, pump and controls and is designed to be placed alongside the machine which it is to serve.
MADE BY—*Industrial Electroplating Co., Inc., 219 W. Vermont St., Indianapolis 4, Ind.* **288**

Sheet Metal

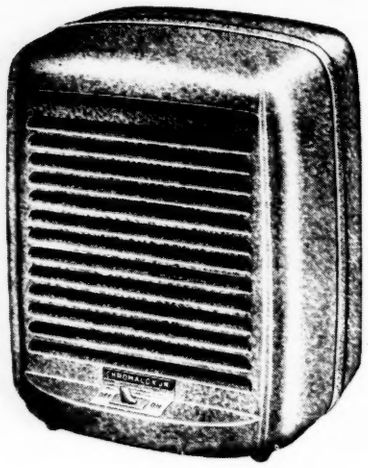
NAME—Eraydo alloy.
PURPOSE—Rustless sheet metal for cold air ducts.
FEATURES—Metal is a combination of zinc, copper and strengthening metals. It is said to retain the corrosion resistant characteristics of zinc and to have the advantages of other non-ferrous metals. Alloy weathers to a neutral gray color and makers claim it will not stain surrounding parts of structure. It solders readily and can be formed with ordinary sheet metal tools. Makers claim it can be flashed into concrete or lumber joints without a protective coating.
LITERATURE AVAILABLE—Folder.
MADE BY—*Illinois Zinc Company, 2959 W. 47th St., Chicago 32*...**289**

Cleaner

NAME—Clean and Etch.
PURPOSE—For removing oil or grease stains from concrete.
FEATURES—Material is poured on solid surface, brushed in, and then rinsed off with water. Fuel oil and grease stains are claimed to disappear.
MADE BY—*Degree Day Systems, 5104 39th Avenue, Woodside, N. Y.* 290

Room Heater

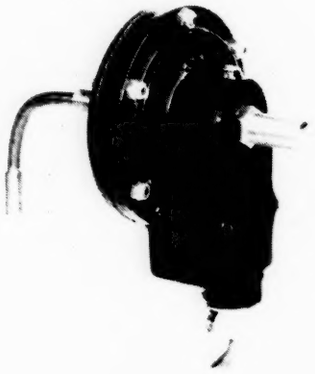
NAME—Chromalox Jr. electric room heater.
PURPOSE—For heating rooms or for auxiliary heating.
FEATURES—A coiled enclosed type electric tubular heating unit is used and a fan moves air through the rear of the heater and forces it over the heating unit.



SIZES AND CAPACITIES — Unit is rated at 1,500 watts and can operate from 115- to 120-volt, 60-cycle a-c current. Case is $11\frac{1}{8}$ in. by $8\frac{5}{8}$ in. by 8 in. deep.
MADE BY—*Edwin L. Wiegand Company, Pittsburgh, Pa.*.....291

Pressure Control

NAME—Sensitive static pressure control, Cat. 101.



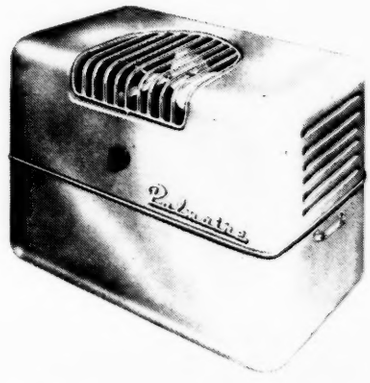
PURPOSE—Pressure regulation at very low pressures.
FEATURES—Sensitivity of unit is provided by a neoprene rubber diaphragm which directly actuates the switch to a simple disc. Range is secured by a precision made spring which is adjusted by a knurled knob. Switch is enclosed in a plastic case. Cut-in and cut-out points are determined by the fixed differential which is said to provide a direct start-stop circuit without use of relays. Close or wide operating differentials can be obtained with the differentials available. Available with double throw circuit or floating contacts for use in connection with reversing type damper control motors.
MADE BY—*Coral Designs, P.O. Box 248, Forest Hills, N. Y.*.....292

Magnesium

NAME—Magnode.
PURPOSE—For use in water tanks to eliminate red water.
FEATURES—Unit is made of special magnesium alloy which has a lower corrosion resistance than the tank which it is to protect. For that reason only the magnesium anode is attacked.
MADE BY—*The Powerad Company, 79 Madison Avenue, New York, N. Y.* 293

Humidifier

NAME—Palmaire humidifier.
PURPOSE—Portable unit for humidifying and filtering air.
FEATURES—A drop system is used to filter, wash and moisturize the air. A slow speed motor and fan draw air through dampened filter pads. Air is then expelled through a chromium grille in the top of the unit. Water is continuously recirculated from a 3 gal. reservoir by a small centrifugal direct driven pump.
SIZES AND CAPACITIES—Unit is 11 in. high, $9\frac{1}{2}$ in. deep, 16 in. long and disperses 12,000 cu ft of washed air per hour.
MADE BY—*Palmer Manufacturing Corp., Phoenix, Ariz.* 294



SEPTEMBER, 1948

TO OBTAIN FURTHER INFORMATION ON NEW EQUIPMENT

On the list below, circle the item number of the equipment in which you are interested, using the number found at the end of each item.

260	261	262	263	264	265	266
267	268	269	270	271	272	273
274	275	276	277	278	279	280
281	282	233	284	285	286	287
288	289	290	291	292	293	294

Print your name and address, detach and mail to
Editor, HEATING AND VENTILATING, 148 Lafayette St., New York 13, N. Y

Name.....

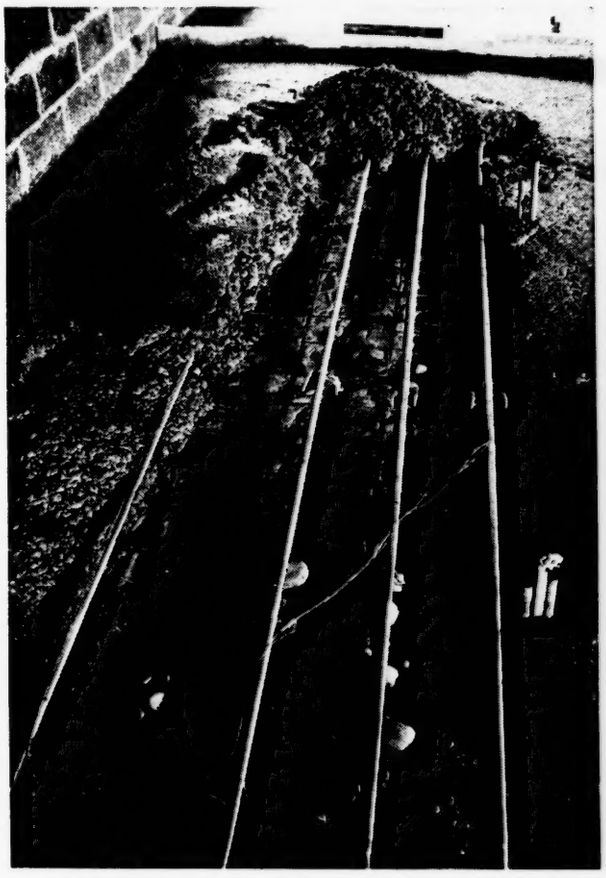
Title (Must be shown).....

Firm (Must be shown).....
(For prompt service, title and firm name must be shown above.)

Business Address.....

City.....**Zone**... **State**.....9 43

HOW REVERE GETS THE FACTS ON RADIANT PANEL HEATING



THE photograph above shows one of the test installations of radiant panel heating set up by Revere, in a building designed for continual occupancy, to develop practical information needed by architects and by engineers and contractors in the heating field. Taken as the concrete is being poured, it shows a three-tube grid type coil located in a concrete floor slab. The fourth tube (farthest left) is part of another three-tube grid type coil.

Note the wires that run across the tubes into the left hand corner of the photograph. These are thermocouple wires that are attached to the copper tube at 8-foot intervals in order to determine the reduction in temperature of the water as it travels through the tube. Additional thermocouples are used to determine temperatures within the concrete floor slab and on its surface at various points in the room. Ground temperatures under the slab have also been recorded.

Throughout the heating season, an installation like this one yields precise, valuable, operational data that are carefully recorded by Revere engineers. Then, this information, together with the results of other research projects, is given to architects, engineers and contractors in such Revere literature as "A Graphical Design Procedure for Radiant Panel Heating," "Radiant Panel Heating—A Non-Technical Discussion," and "Radiant Heat with Copper Tubing."

In all probability these books are now in your files. Be sure to refer to them whenever you need reliable data on the design or installation of radiant panel heating systems.

And be sure to specify Revere Copper Water Tube—readily available through leading distributors. This long-lasting, easy-to-bend tube is ideal for radiant panel heating. Remember—trouble always costs more than Revere Copper Water Tube.

REVERE

COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

230 Park Avenue, New York 17, New York

• • •

Mills: Baltimore, Md.; Chicago, Ill.; Detroit, Mich.; New Bedford, Mass.; Rome, N. Y. — Sales Offices in Principal Cities, Distributors Everywhere.

NEWS OF THE MONTH

AIR CONDITIONING

from central station provided for stores in new housing project.

In the first such project of its kind, air conditioning from a central point is being furnished to the stores, professional offices, and a motion picture theater in the 16-acre shopping center of a multi-million-dollar housing project in New York City, Carrier Corp., Syracuse, N. Y., has announced. In providing this service, New York Life Insurance Company, the builder, has recognized air conditioning as a necessity for modern stores—just as fundamental to their operation as heat, light and water service.

• **PROJECT.**—The installation is being made at Fresh Meadows, Long Island, where, on a 170-acre tract, a half-hour from the heart of New York, a completely integrated community for 10,000 persons is being built. It includes 3,000 apartments, playgrounds, landscaped lawns, garages, model shopping district, and a new public school.

• **SYSTEM.**—To furnish air conditioning for the shopping center, chilled water, piped through more than a mile of 12-inch pipe under a 100-pound head pressure, will be delivered to the individual stores. To provide this service, two 600-ton electric-driven Carrier centrifugal compressors have been installed in the central power station.

This centralized distribution of chilled water relieves the individual stores of installing their own compressors, and provides them with complete air conditioning service on an extremely economical basis. It eliminates the need for large individual electric service, and the necessity of obtaining and disposing of the condenser water. The Carrier compressors in the central plant will be supplied with condenser water from two specially bored wells. The used water from the condensers will be returned through two diffusion wells to the same underground strata from which it is pumped. Further economy results from the fact that the central power station staff will maintain and service the compressors, relieving the store owners of individual machine maintenance.

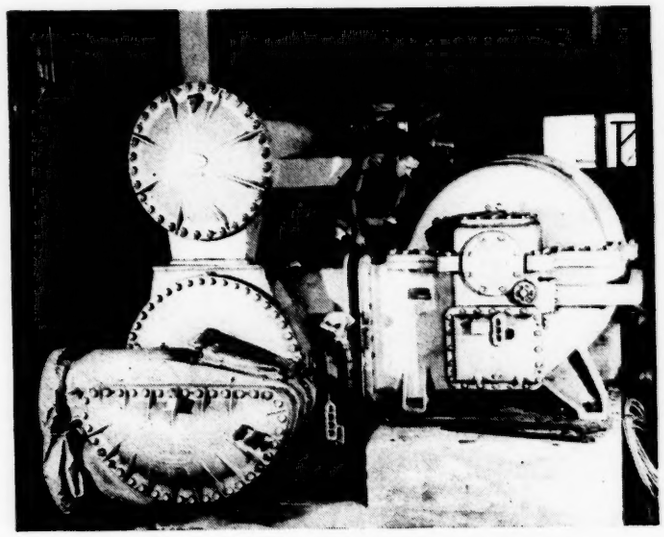
Air ducts, fans and all necessary adjuncts for an air conditioning system are being installed in the stores as they are built.

The two 600-ton Carrier compressors will operate automatically, varying their production of chilled water according to the "load" required by the prevailing temperature and humidity.

The outstanding features of this unusual central station air conditioning installation are described by H. E. Meeker, of the firm of Meyer, Strong and Jones, consulting engineers, New York, which designed the system, as follows:

• **ECONOMY.**—"One of the principal advantages of the central refrigeration plant planned for this development, is the economy it will effect in initial cost and in annual maintenance and operating cost. The refrigeration machinery and chilled water pumping equipment will be installed in an extension of the central high pressure boiler plant. This arrangement will allow the refrigeration plant to be operated and maintained by the boiler plant operating force under the direct supervision of the chief engineer. As compared with individual plants for each air conditioned building or tenancy, the saving in operating and maintenance cost, as well as first cost, will be much greater.

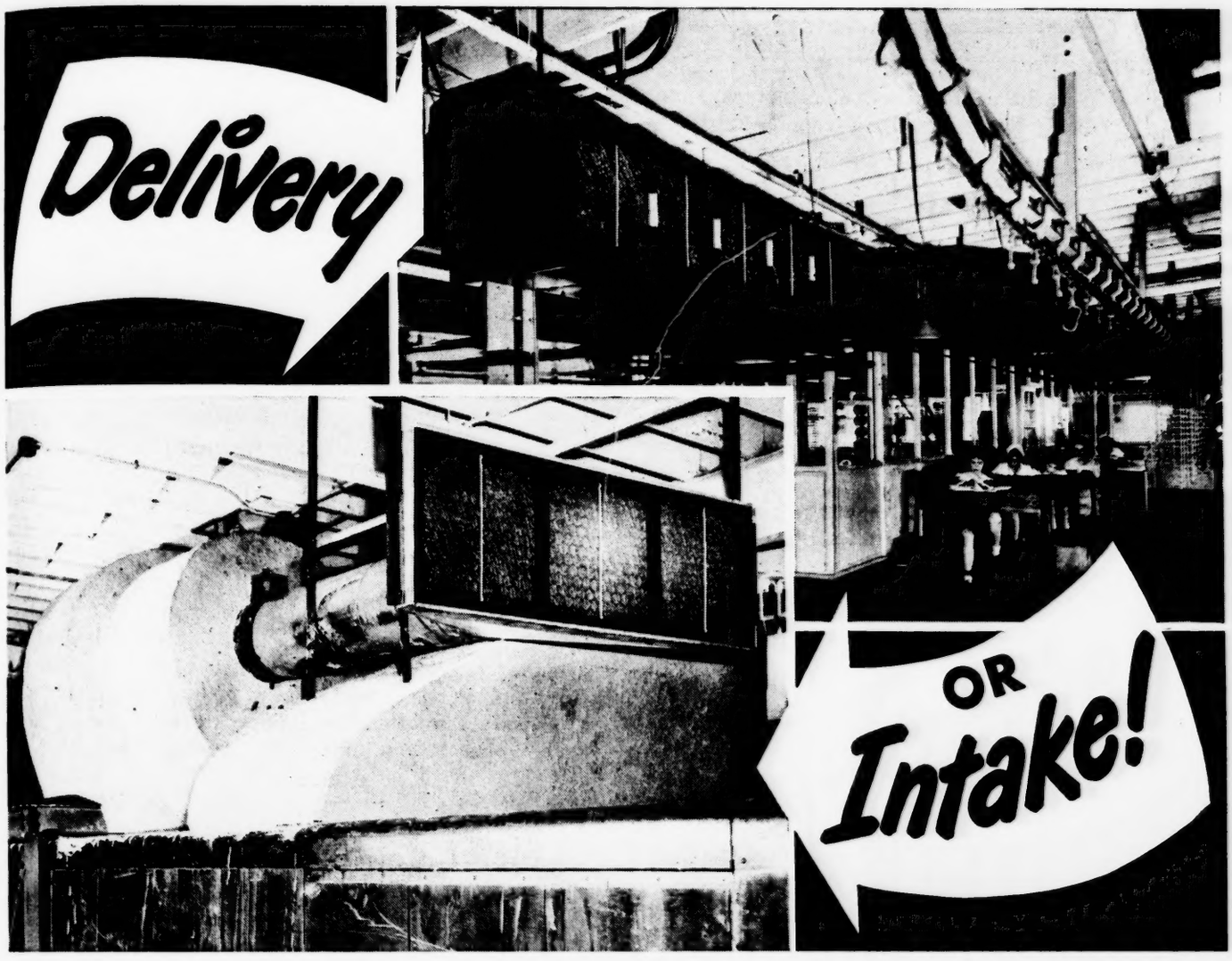
• **FLEXIBILITY.**—"In addition to the considerable cost advantage of the central system, it is a much more flexible scheme than individual plants in that no provision need be made in the design of individual buildings for refrigeration equipment, cooling towers, or other such items. Furthermore, subsequent changes in tenancy can be taken care of easily, with relatively slight structural changes to the building. Another important advantage of the central system is the greater flexibility provided for future extension of air conditioning facilities to future tenants.



Centrifugal compressor for central station air conditioning.

• **METERING.**—"An unusual feature, applying to the larger air conditioning systems of the project, is the metering equipment provided for measuring the chilled water. These meters measure not only the volume of the chilled water used but also take into account the temperature rise of the chilled water through the air conditioning equipment. These two factors are integrated and totalized in terms of million Btu units. It is believed that the application of such meters in connection with the sale of refrigeration for air conditioning is unique with this development."

Architects for the project are Voorhees, Walker, Foley & Smith, of New York, with Meyer, Strong and Jones as consulting engineers. The general contractor



Wherever air must be cleaned efficiently, economically, install DUST-STOP* Air Filters

Low original cost! Low maintenance cost! Exceptional ease of maintenance! High dust-catching efficiency! These advantages of DUST-STOP Air Filters are outstanding for commercial and industrial installations where high standards are set for clean air . . . and where economy, too, is important.

And there are other good reasons why DUST-STOP Air Filters are specified by heating, ventilating and air-conditioning engineers. The packs of Fiberglas fibers make an exceptionally efficient filter medium. Being glass, and inorganic, the fibers have no odor, nor will they rot or decay. They do not absorb the non-odorous, non-evaporating adhesive with which they are coated. As a result, each impinged particle of dust is quickly soaked, maintaining the filter's high efficiency until the DUST-STOP is so heavily loaded that resistance to air flow calls for replacement.

These replacement-type filters can be installed in custom-built frames, or in complete ready-to-assemble DUST-STOP metal frames that are adaptable to meet all space and air volume requirements. For complete details, write for descriptive folder D-48-7. Owens-Corning Fiberglas Corp., Dept. 912, Toledo 1, O.

In Canada: Fiberglas Canada Ltd., Toronto, Ontario.

DUST-STOP* AIR FILTERS
–a Fiberglas† product

*T. M. REG. U. S. PAT. OFF.

†FIBERGLAS is the trade-mark (Reg. U. S. Pat. Off.) for a variety of products made of or with glass fibers by Owens-Corning Fiberglas Corporation

is the George A. Fuller Company. J. L. Murphy, Inc., was awarded the heating and air conditioning contract.

Supervising the project for New York Life are G. Harmon Gurney, chief architect, and Richard T. Geoghegan, construction engineer, of the housing department.

New York Life hopes the entire project can be completed and entirely occupied before the summer of 1949.

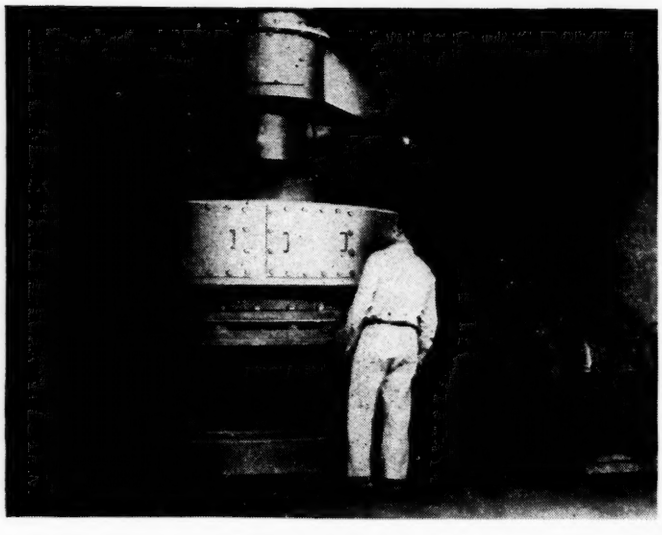
PULVERIZED COAL SYSTEM

installed in cement plant is largest ever built and first of type in the industry; successfully fires three rotary kilns.

The largest capacity circulating system ever built for firing pulverized coal has passed initial operating tests and goes into regular supplementary service this fall in a midwestern cement plant, The Babcock & Wilcox Co., which manufactured and installed the equipment, has announced.

• **STANDBY.**—The system, the first of its kind in the cement industry, was designed as a standby fuel supply for kilns of the Universal Atlas Cement Co. at Independence, Kan. It has been tested during the past few months and is ready for use during the winter when the supply of natural gas is frequently inadequate.

• **DESIGN.**—The system has a continuous loop of piping 275 ft long over-all through which the coal and air mixture from a single pulverizing unit circulates continuously to the plant's four rotary kilns. Operation has proved successful in complete coal firing of from one to three kilns at one time and it is possible that further experimentation with a combination of natural gas and pulverized coal in the pipe may make it possible to fire all four kilns simultaneously with a mixture which is up to 75% pulverized coal.



Coal pulverizer.

The coal mill is an E-70 B. & W. pulverizer, the largest single race pulverizer built by the company. It is 12 ft high, with a windbox which has a 9-ft-10-in. outside diameter. Capacity of the mill is rated at 18,250 lb of coal per hour.

The system was designed for simultaneous firing of two kilns with a peak fuel demand of 15,240 lb of pulverized coal per hour, but with normal kiln output and fuel demands and with average quality and grindability coal, the system meets the requirements of three kilns at once.

• **SAFETY.**—The distributing pipeline operates with a surplus of primary air-coal mixture which is recirculated back to the pulverizer exhaust fan. The diameter of the pipeline is progressively smaller from beginning to end to compensate for the successive removals of fuel for the kilns of the line. Feeding of coal into the pulverizer and discharge of pulverized coal into the pipeline are controlled automatically. The circulating system which eliminates storage of pulverized coal is constructed to remove fire hazards and is designed to withstand an explosion pressure of 50 lb per sq in. It has a safety factor of four and should an explosion occur the fire is carried on through the burner pipes to the kilns where it is harmless.

RADIANT BASEBOARD

passes tests in basementless house of University of Illinois.

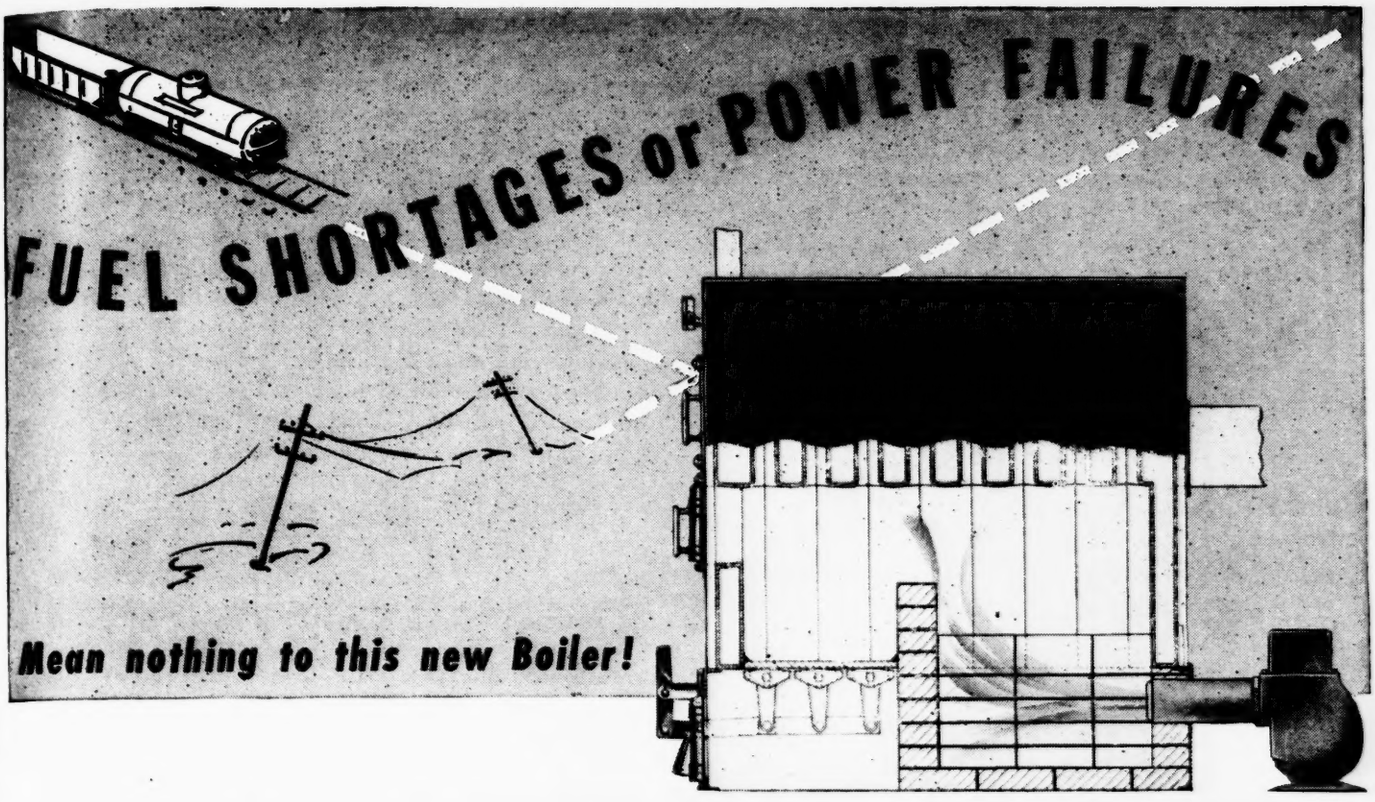
"Very satisfactory results" have been obtained in tests of the performance of a radiant baseboard heating system in a basementless house, according to Professor Warren S. Harris, of the Department of Mechanical Engineering of the University of Illinois.

• **PROGRAM.**—The Institute of Boiler and Radiator Manufacturers has been cooperating with the university in research work which has already tested the radiant baseboard in the I-B-R Research Home just off the campus of the University of Illinois.

The heating system used in the basementless house was a one-pipe, forced circulation, hot-water system designed to operate with an average radiator temperature of 215F at —10F outdoor air temperature.

• **RESULTS.**—Results, briefly, were summarized by Professor Harris as follows: With the thermostat set to maintain 72F at the 30-in. level, slab surface temperatures in the center of the room never dropped below 67F. Where radiant baseboard was in use, the surface temperature of the slab one foot from the outside wall was 72F during zero weather, and only 60F one foot from a wall where radiant baseboard was not used.

The average air temperature difference between the floor and ceiling varied from 1.7F in mild weather, 5.0F when the outdoor temperature was —5F. In zero weather the average air temperature 3 in. above the floor was only 2F cooler than at the 30-in. level. Seasonal fuel consumption was about the same as that



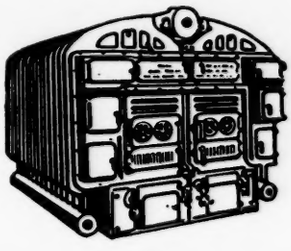
Presenting the Smith-Mills RELIANCE · · for larger homes

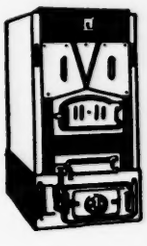
Even the best automatically-fired boiler is subject to the whims of Nature or man—whether in the form ot power failures, strikes, or curtailed fuel delivery or supply. Acknowledging this, H. B. Smith has designed an automatically-fired boiler for both normal and emergency operation. *If for any reason either fuel supply or electric power fails, the Smith-Mills RELIANCE still maintains a comfortable, healthful level of heat in the home.*

An emergency grate makes this possible. With it, a *coal* fire can be maintained to give ample heat and domestic hot water as long as they are needed. Yet this arrangement in no way lowers boiler efficiency during automatic firing, as the ratio of heating surface to combustion area is actually greater than in conventional boilers of comparable size.

As the emergency grate is an integral part of the boiler, no special mechanical knowledge or skill is required to start the emergency coal fire. It is only necessary to remove the insulating board from the grates and build a regular coal, coke or wood fire.

THE SMITH-MILLS RELIANCE IS NOT FOR *EVERY* HOME. But it is bound to have wide acceptance among those home owners who can afford the utmost in convenience and reliability. This in turn means unequalled client satisfaction for the architect and contractor.





H.B. Smith
CAST-IRON BOILERS

THE H. B. SMITH CO., INC., 63 MAIN ST., WESTFIELD, MASS. • Offices and Representatives in Principal Cities

obtained in the I-B-R Research Home. The Research Home and the basementless house have about the same calculated heat losses, about 43,000 Btu per hr at an indoor-outdoor temperature difference of 80F.

• **DIRT PATTERNS.**—Near the end of the heating season faint dirt patterns could be detected in the kitchen but otherwise walls remained clean. Draperies hanging over the radiant baseboard throughout the winter were not in need of cleaning. Previous experience in the I-B-R Research Home has indicated that dirt patterns may form on the wall above the radiant baseboard if the water temperature exceeds 200F. If the water temperature does not exceed 200F, there is little likelihood of trouble of this kind.

HEAT FLOW ANALYZER

rebuilt at Columbia to solve unusual problems in heat transfer.

An improved analyzer which will take the guesswork out of many industrial and scientific problems was revealed recently at Columbia University, New York, N. Y.

• **REBUILT.**—Countless problems, it is said, can conceivably be solved by the device which has already helped industry remove the element of guesswork from problems relating to heat flow. It is a specialized type of calculating machine developed at Columbia's School of Engineering and is known as a "Heat and Mass Flow Analyzer Laboratory." Equipment in the laboratory, which was originally established in 1940-1941, has been rebuilt and its facilities greatly increased.

As a result of these improvements the calculating machine is now prepared to undertake many unusual projects, according to Dr. Victor Paschkis, technical director, and associate professor Carl F. Kayan, administrative director of the laboratory. The question of when to extract a bad tooth may be determined in the engineering laboratory long before the dentist peers into a patient's mouth, and geologists in the near future may be able to compute the geological age of the earth by exact methods also determined by engineering techniques.

• **ANALOGY.**—This ability of the calculating machine to circumvent the barriers of time, space, and material substance is one of the analyzer's most important characteristics. Its principle is based on the "electric analogy" method, which means that flow of heat is measured in the same way as electric current, according to a report in *Mechanical Engineering*. This makes it possible to use what is termed the "lumping procedure" of electrical measurements—a technique that permits measurements to be made by concentrating the properties of materials in individual circuit elements such as resistors and condensers.

• **SCOPE.**—It is said that samples of material to be tested do not have to be used directly. All that is required are the thermal properties of the material involved and their size and shape.

During the last six years the laboratory has undertaken many problems submitted by industry. Among them have been the following: Heat flow of regenerators, such as are used in the steel and glass industries; heat-transfer problems involved in the solidification of metals, such as castings and ingots; analysis of heat losses in furnace; the problem of de-icing of airplane windows at high altitudes; heat generation of brakes on trains and airplanes; and specific heat-flow problems of industry, which have been solved by use of the analyzer as a calculating machine.

NATURAL GAS CAPACITY

may be increased by project to remove inert nitrogen in large quantities.

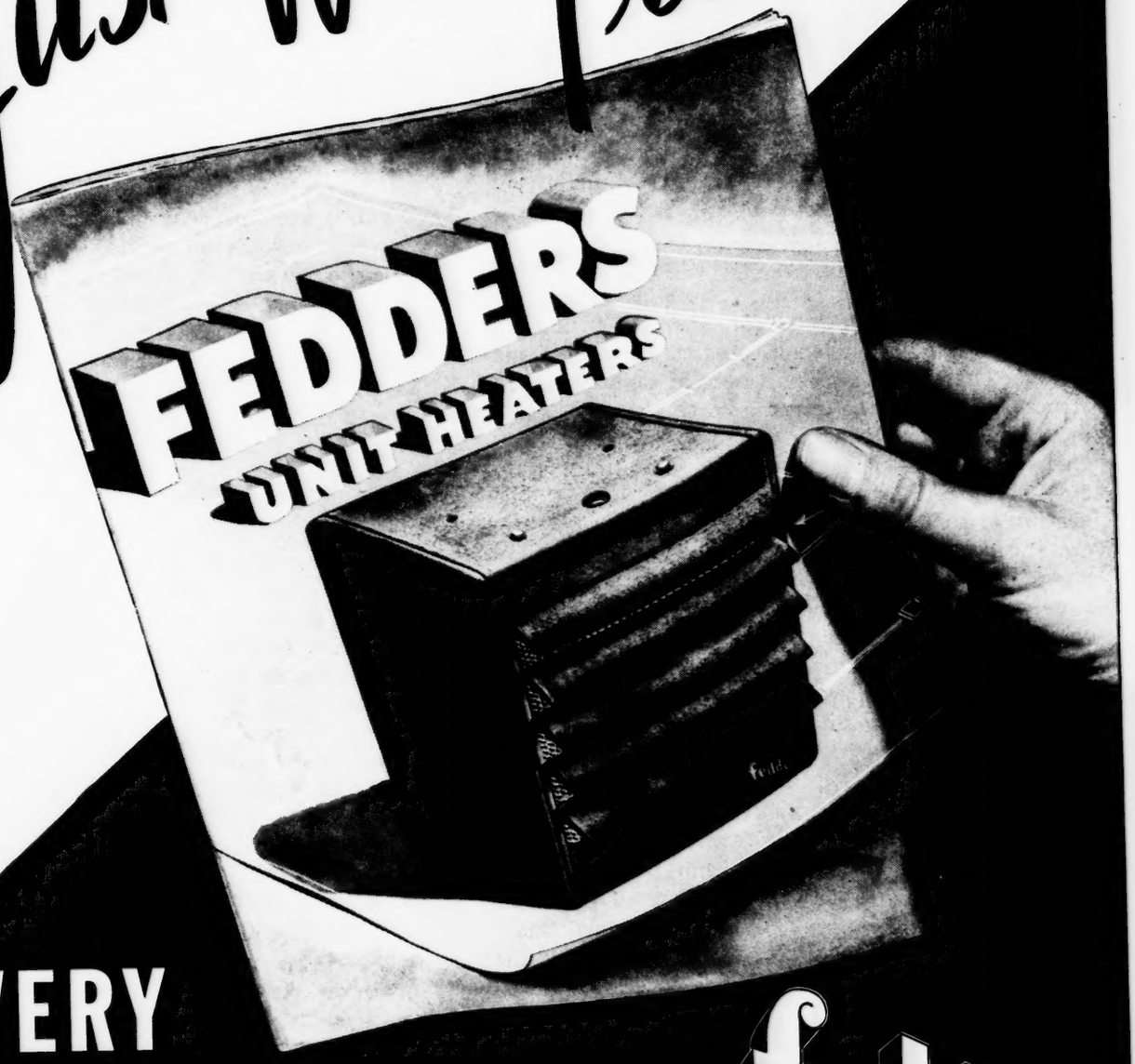
Peak load problems have been a major concern of the gas production research program of the American Gas Association. Manufactured gas plants and large pipe line systems today are operating at capacity loads with demand for gas increasing. In many instances pipe lines are transporting natural gases containing 10% or more of non-combustible nitrogen. Large reserves of natural gas have been developed in some areas which have been limited because of the low heating value resulting from high nitrogen contents. Removal of a large part of nitrogen from this natural gas would greatly increase the present capacity of these pipelines, enabling them to carry a greater quantity of natural gas of higher heat value.

• **MEETING.**—The U. S. Bureau of Mines and AGA have undertaken a cooperative study of the removal of nitrogen from natural gas. More than $100,000 will be spent on a project intended to increase transmission capacity of natural gas pipelines and to improve marketability of natural gas containing non-combustible nitrogen. The Bureau of Mines sponsored a special meeting and round table discussion at Amarillo, Tex., on August 16-17, for engineers of gas companies and others interested in this problem.

• **MOTIVES.**—The Bureau of Mines is interested in nitrogen removal because of its close association with operating problems at the Bureau's helium plants. AGA has undertaken this project as one phase of its expanded research program, which calls for expenditures of $1,800,000 over a three-year period, on the problems of gas production and utilization.

• **PILOT PLANT.**— Detailed studies of physical and chemical means of removing nitrogen from natural gas have been made. A nitrogen removal pilot plant unit has been completed permitting test runs. The purpose of the meeting at Amarillo is to permit engineers to obtain greater familiarity with the technical and economic phases of the problem and the prospective means for its solution, particularly by liquefaction and fractionation.

Just off the Press



EVERY HEATING MAN *is invited to send for this Helpful Data Book*

● Complete specifications, installation and performance data is given in this helpful new catalog covering Fedders Series 15 Horizontal Unit Heaters. Steam and hot water capacities together with conversion factors for various conditions aid in specifying correct equipment. Heater location, wiring and piping diagrams, throw distances, and heat transmission coefficients put essential data at your finger tips. Write for your copy.

fedders

Series 15

UNIT HEATERS

FEDDERS-QUIGAN CORPORATION • BUFFALO 7, N.Y.

WARM AIR FURNACES

responsible for half of U. S. house heating, to get voluntary steel allocation. Summary shows use and price trends.

The first voluntary allocation agreement, concluded under 1947 Public Law 395 covering the production of building materials for housing, is intended to channel 233,000 tons of steel to manufacturers of warm air heating equipment during the eight-month period from July 1, 1948, to February 28, 1949. The steel allocation will be shared by manufacturers of warm air furnaces, registers and grilles, furnace blowers, furnace pipe, fittings, and duct-work and floor and wall furnaces. Under terms of the agreement, the major portion of the allocation—125,000 tons—will go to manufacturers of warm air furnaces.

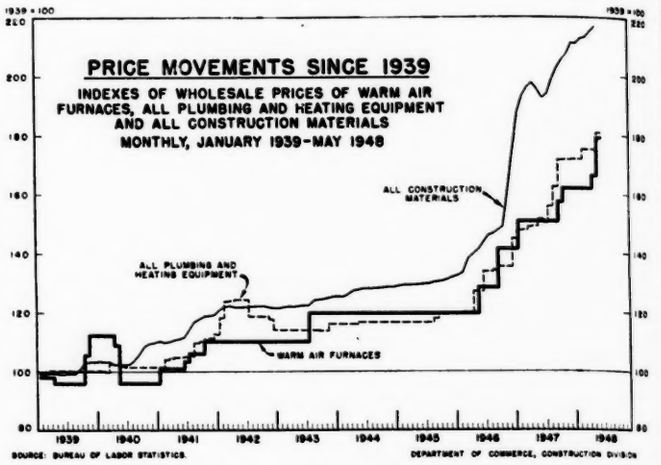
Intensification of interest in the warm air furnace industry seems certain to follow the conclusion of this agreement—a possible model for future allocation programs covering production of other major building materials. Therefore the Department of Commerce Construction Division has issued a summary of pertinent available data on the warm air furnace industry. Extracts of the Division's report follow:

• **EXTENT.**—Although utilized to some extent for the heating of commercial and industrial buildings, warm air furnaces are used predominantly for the heating of homes. Available data indicate that approximately half of the homes built since the end of the war are being heated by means of warm air furnaces. In meeting this demand, and a concurrent replacement demand for furnaces worn out after long periods of service, the industry shipped out some 845,000 warm air furnaces with a gross f.o.b. factory value of approximately $140,000,000 in 1947.

The 1940 Housing Census reported that 2,743,000, or some 40% of the warm air furnaces then in use in occupied dwelling units were within the borders of the East North Central Census Region. The Middle Atlantic States contained 22% of the national total; the West North Central States 15%; the Pacific Region 9% and New England 5%.

Under the impetus of the postwar reconversion and veterans housing programs, the industry almost doubled its 1945 output record in 1946, producing what was then a record total of 706,000 furnaces. This peak was destined to short-lived; the industry followed through with another record (877,000) in 1947. Output during the first few months of 1948, however, has been substantially below 1947 levels.

• **PRICE MOVEMENTS.**—Between 1939 and May 1948, according to the data supplied by the Bureau of Labor Statistics, prices of warm air furnaces are estimated to have increased by 79%—an increase roughly paralleling the average change in prices of all plumbing and heating equipment items, but somewhat less than the average price change of all construction materials during the same period. A chart, tracing the course of monthly indexes of wholesale prices for these three items since January 1939 is presented.



The indexes of warm air furnace prices shown in the chart have been compiled by the Bureau of Labor Statistics on the basis of data from a selected sample of warm air furnace producers, and cover price changes for a specified type of cast iron, solid fuel-burning, gravity flow furnace. While this sample has not as yet been scientifically tested for reliability, the Bureau believes that these indexes are a fairly accurate representation of price movements within the industry during the period shown.

As the chart indicates, prices of warm air furnaces were somewhat erratic during the pre-war period. On the other hand, the war period, under OPA price controls, was one of comparative price stability, with changes occurring somewhat infrequently and with such price movements as did take place being consistently upward. Index numbers for this period are based solely on fixed OPA prices.

• **FUEL.**—Oil and gas furnace output expanded both relatively and absolutely during 1944 and 1945—with gas furnace output reaching 14% of total reported production in 1945; oil, 4%; while output of solid fuel furnaces receded to 82% of the total. By 1946, the pre-war (1941) output proportions were restored practically intact—solid fuel amounting to some 57%, gas 32%, and oil 11% of total production. At this time, NHA, as part of its previously mentioned housing survey, reported that—of new dwelling units then being planned—27% were designed to burn coal, 21% oil and 52% gas.

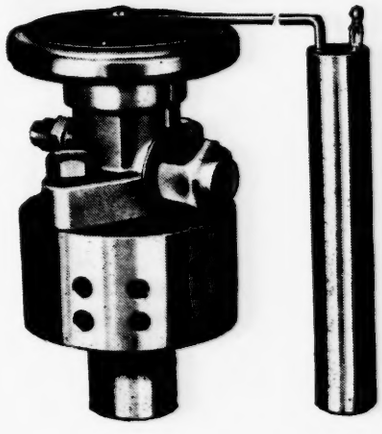
During 1947, output of furnaces designed to burn solid fuel, for the first time on record, failed to account for more than half of total industry production. Oil furnace output during 1947 more than quadrupled over that of the previous year; production of this type accounting for some 36% of the year's record volume. Output of solid fuel furnaces fell to 41% of the total; that of gas to 23%.

Although the fuel oil situation for the coming heating season still seems uncertain, and gas supply difficulties are reported in certain areas, oil and gas furnace output combined constituted more than half of total furnace production thus far in 1948. Through April of this year, output of solid fuel furnaces has amounted to 48% of the total reported; oil furnaces, 29%, and gas furnaces, 23%.

When poor distribution "short-circuits" the refrigerant through only a few passes, coil capacity is often cut ⅓ to ½ — efficient control is impossible — operating costs climb.

ALCO Multi-Outlet Thermo Valves assure:

- The refrigerant liquid is accurately metered at the point of expansion to all coil circuits
- Even distribution despite load variations
- Full rated coil capacity—every circuit on the job
- Instant, alert control—no "hunting" or "cycling"
- Higher operating suction pressure—more efficient compressor operation at lower cost



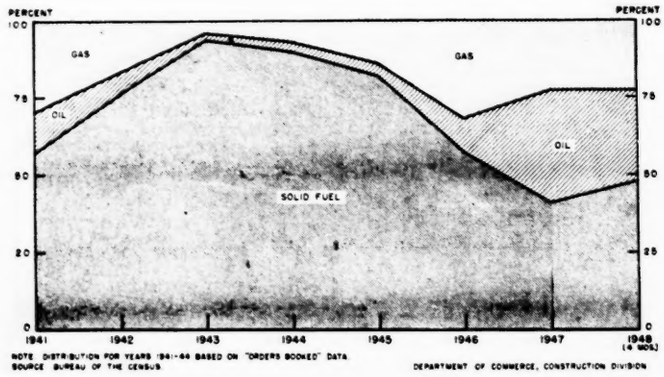
Available at your wholesaler's for all refrigerants, all applications: ½ to 50 tons FREON-12, 2 to 36 outlets. Ask for our Bulletin 180.

ALCO

ALCO VALVE CO.

859 KINGSLAND AVE. • ST. LOUIS 5, MO.

Designers and Manufacturers of Thermostatic Expansion Valves; Evaporator Pressure Regulators; Solenoid Valves; Float Valves; Float Switches.



Percent of total furnaces designed for coal, oil, or gas.

During April of 1948, 72 of the 150 plants reporting production of warm air furnaces produced solid fuel furnaces, according to the Census Bureau—many producing other fuel-burning types as well. Oil furnace production during that month was reported by 102 plants, while 67 plants reported they were manufacturing gas-fired warm air furnaces.

• **FORCED AIR VS. GRAVITY.**—With the added blower units, initial costs of forced air furnaces are generally considerably higher than for gravity furnaces. For the first four months of 1948, the average value of forced air furnaces (unit value of shipments) at the manufacturers' level was $220; that of gravity furnaces, $119. These figures represent a 37% and 47% increase, respectively, over 1941 figures for unit values of orders booked ($161 and $81).

In 1947, for the first time, forced air furnace output exceeded that of gravity furnaces, the relative proportions being 54% and 46%, respectively. Output records for the first four months of 1948 show little change in these ratios—forced air furnace production amounting to 53%, and gravity, 47% of the total.

In April 1948, 128 of the 150 Census-reporting plants indicated production of forced air furnaces during the month. Gravity warm air furnace production was reported by 85 plants during that month.

• **STEEL VS. CAST IRON.**—Cast iron furnaces are generally of sectional construction, the various component sections being cemented or bolted together in final assembly. Frequently this is done at the installation site. Cast iron furnaces are produced in round and square shapes, and in a multiplicity of different designs—depending primarily on the type of fuel and air circulation for which the furnace is intended.

Steel furnaces are generally constructed of formed sheet steel, the parts joined together into the final assembly at the plant by welding or riveting. At present (average for the first four months of 1948) the average unit value of steel furnace shipments is slightly higher than that of cast iron ($178 against $150), probably due to the fact that the more expensive oil and gas furnaces are generally of steel construction. In 1941, when oil and gas furnace output accounted for smaller shares of the total, unit values of steel and cast iron furnaces were almost identical.

Since the end of the war, output of the industry has been marked by the growing predominance of steel furnaces. In 1945, steel furnaces accounted for approximately 64% of industry production; cast iron, 36%. These ratios shifted to 78% steel and 22% cast iron in 1947. Output records for the first 4 months of 1948 indicate no change in the 78-22% ratio.

In April 1948, the Census Bureau reports, 125 of 150 reporting warm air furnace producers manufactured steel furnaces during the month. Cast iron furnace production was reported by 52 plants.

• **PRODUCTION.**—While stock levels were moving sharply upward, production during the first 4 months of 1948 declined considerably from the peak months of 1947. Output during these 4 months totaled 216,000 units—a decrease of 28% from the corresponding period of 1947. Accompanying this decline was an even more marked drop in industry shipments from the corresponding period of last year; units shipped decreasing from 258,000 to 168,000—a 35% decline.

Although it has coincided with a decline in shipments and a rise in stocks, the industry generally has attributed the current drop in the output rate to drastically curtailed receipts of steel and pig iron supplies. A survey of the industry conducted by Dun and Bradstreet, Inc., for the National Warm Air Heating and Air Conditioning Association indicated that steel and pig iron receipts by warm air furnace producers during the first quarter of 1948 were 45% below first quarter 1947 receipts, and somewhat below the quantities received in the first quarter of 1946.

With this background, the 1948 output drop appeared to be of sufficient magnitude to bring into question the industry's ability—without some assurance of obtaining needed supplies of primary metals—to meet production quotas for a one million unit 1948 housing program, while still filling essential replacement orders. This, in brief, is the background of the industry voluntary allocation program.

• **VOLUNTARY ALLOCATION.**—Early in 1948, in accord with the provisions of Public Law 395, passed in Special Congressional Session at the end of 1947, a new office—known as the Office of Industry Cooperation—was established within the Department of Commerce. Specified task of this office is to cooperate with industry groups to formulate voluntary agreements to allocate supplies of scarce basic materials to a limited number of specified critical programs, among which is housing construction.

During March and April, representatives of a number of housing material industries engaged in a series of exchange-of-information conferences with the O.I.C. Discussion at these initial conferences centered on exploring the desirability and feasibility of setting up voluntary allocation programs to cover output of these materials. First meeting with the warm air furnace industry was held on April 16.

At this meeting, attended by 25 leading industry representatives, attention was drawn to the falling output rate during 1948 and to the drop in manufacturers' receipts of steel and pig iron. It was the general consensus of the industry representatives, O.I.C.

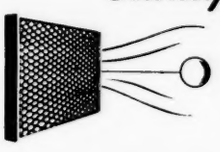
(Concluded on page 117)

FAR-AIR Grease Filters protect the cafeteria kitchen of Briggs Manufacturing Co., Detroit, Michigan.

GREASE MAKES FIRES

FAR-AIR® *Grease* FILTERS STOP GREASE IN DUCTS

TEST YOUR
AIR FILTERS
Yourself



Farr Company has originated a simple procedure for testing your air filters in place. Find out if your air filters are operating efficiently. Write for full information.

Send for the FAR-AIR Catalog for complete information on Grease Filters. Address: Farr Company, Dept. G, 2615 Southwest Drive, Los Angeles 43, Calif.

KEEP KITCHENS *MODERN, SAFE, CLEAN*

Accumulation of highly combustible grease in the exhaust systems of restaurant kitchens builds up a dangerous—and unnecessary—fire hazard. Modern restaurant design avoids fire loss from grease deposits by installation of FAR-AIR Grease Filters, protecting ducts, fan and blower equipment and giving improved ventilation, cleanliness and safety.

HERRINGBONE-CRIMP construction of FAR-AIR Grease Filters permits their being flushed clean of grease by sloshing in hot, soapy water. Quick cleaning combined with easy installation and removal makes them the specified choice of architects, engineers and contractors.

Among the users of FAR-AIR Grease Filters are: Underwriters' Laboratory; F. W. Woolworth Co.; Chrysler Corp.; Hotel Statler, Boston; Longchamps, N.Y.C.; Earl Carroll's, Hollywood; Federal Reserve Bank of N. Y.; Hotel La Salle, Chicago; U. S. Armed Forces.

herringbone-

FAR-AIR FILTERS

"Better by Farr"

-corrugations

FARR COMPANY
Manufacturing Engineers

Los Angeles
Chicago • New York

REPRESENTATIVES IN PRINCIPAL CITIES OF THE UNITED STATES AND CANADA

Abstracts AND Reviews

Publications abstracted in this department should be ordered direct from publisher.

WINTER AIR CONDITIONING

Prepared in a readable style, Warm Air Heating and Winter Air Conditioning, by John W. Norris, vice-president, The Lennox Furnace Co., is intended to serve as a guide to the student and to the man in the field. This manual covers not only the engineering fundamentals but also installation and servicing of all types of warm air heating equipment.

The author has tried to cover every phase of warm air heating and winter air conditioning to acquaint the student with the various problems of this heating field. Mr. Norris has had the cooperation of The Lennox Furnace Co. engineering staff in the preparation of charts, tables and other material.

The book is divided into 20 chapters, which cover in part: Types of heating systems; computation of heat losses from buildings; selection of equipment; designing a gravity warm air heating system; winter air conditioning; adjusting, balancing and servicing; properties of air; air cleaning; thermostatic controls; coal, gas and oil furnaces; industrial and commercial warm air installations; solid fuels and their combustion; chimneys and flues; useful tables.

Warm Air Heating and Winter Air Conditioning, by John W. Norris. Cloth bound, 8½ x 11 in., 320 pages. Published by The Lennox Furnace Co., Marshalltown, Ia. Price, $5.

• • •

ELECTRIC LIGHT AND POWER DATA—Statistical Bulletin—Year 1947 for the Electric Light and Power Industry in the United States contains a large amount of data regarding the generation and use of electric power. The figures cover plant and operating statistics for the entire electric light and power industry. Bases for the data are the reports made directly to the Edison Electric Institute and to the National Electric Light Association. Paper bound, 39 pages, price 75c. Edison Electric Institute, 420 Lexington Ave., New York 17, N. Y.

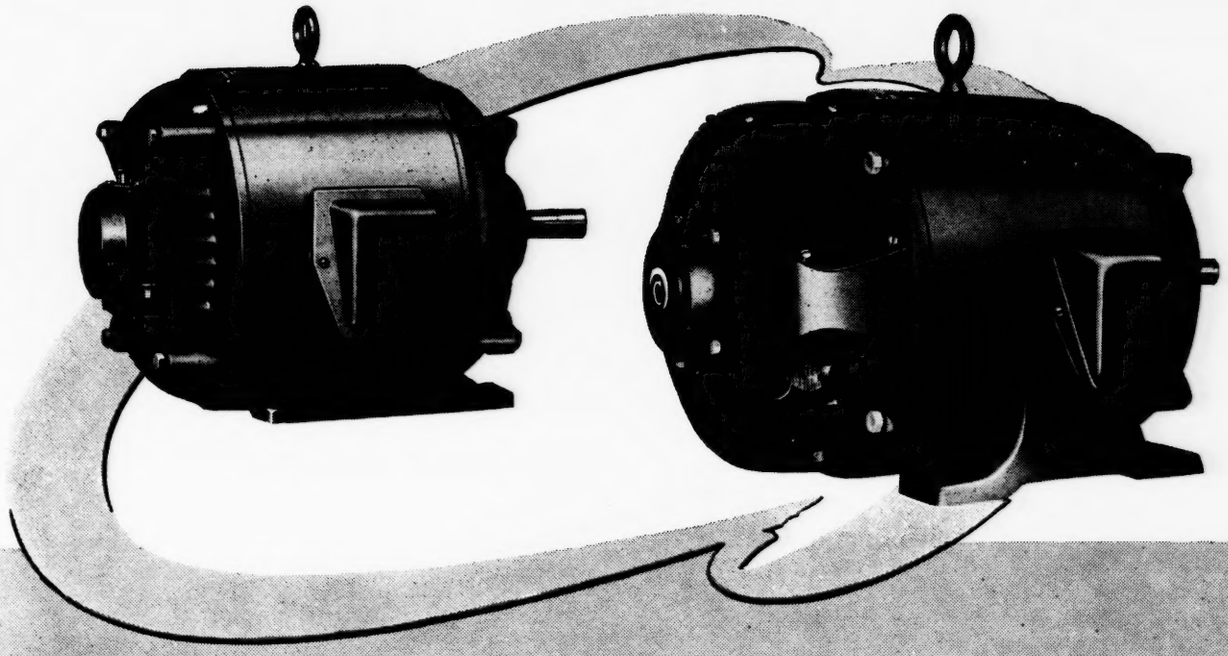
VENTING DIRECT GAS HEATERS—Sponsored by the American Gas Association, an investigation was carried on by the Purdue Research Foundation, on gas appliance venting practices. The report is presented in a 68-page illustrated booklet on Research in Venting Direct Gas Heaters When no Chimney Connections are Available. The investigation was limited to conditions beginning at the outlet of draft hoods and the report summarizes work completed to January 1, 1947. The report discusses the basic problems involved in successful venting, and shows by illustrative examples why some installations fail and what can be done to overcome such conditions. The project is continuing at Purdue with the objective of developing a practical manual. American Gas Association, 420 Lexington Ave., New York 17, N. Y. Price, $1.

PERFORMANCE OF A CONVERSION JOB—Report BMS 111, Performance of a Coal Fired Boiler Converted to Oil, an 11-page report, discusses the problems of efficient coal to oil conversion. It contains data on the performance of a cast iron boiler designed for coal firing after it had been converted to the use of oil by means of a gun-type burner. Results of this work establish the general possibility of improving the efficiency and increasing the ratings or capacities of boiler after conversion. Most of the data appears in an article in HEATING AND VENTILATING, May, 1948, pp 65-68. For a copy of report write to Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price, 15c.

STORE MODERNIZING GUIDE—Within its 49 illustrated pages are the latest facts regarding the planning of community shopping centers, store exteriors, fixtures, lighting and layouts. Included are articles on ventilating food stores, air conditioning, and dual temperature rooms. Guide is published by the National Association of Retail Grocers, 360 N. Michigan Ave., Chicago 1, Ill.

HOUSEHOLD HEATING—A research bulletin on Supplying Household Heating Services by High Temperature Circulating Liquids and Vapors presents the results of research carried on at the Institute of Gas Technology, Chicago, under the sponsorship of the American Gas Association. The study covers not only the technical considerations of the problem but also discusses the economics involved. It has been proposed on many occasions that the use of high temperature liquids and vapors as a heat transfer media would improve the performance of domestic appliances. Paper cover, 22 pages. Price, $1. American Gas Association, 420 Lexington Ave., New York 17, N. Y.

ILLINOIS SMOKELESS FURNACE—Professors Fellows, Kratz and Konzo of the University of Illinois have prepared Bulletin Series No. 370 on the Illinois Smokeless Furnace. The authors present information on the development of this type furnace and results of tests on this furnace both at the laboratory and in a research residence. Details of the construction of the furnace are described and illustrated. Engineering Experiment Station, University of Illinois, Urbana, Ill. Price, 75 cents.



To Start Heavy Loads—With Low Starting Current

...Use Century Type RS Single Phase Motors

Century Type RS, repulsion start, induction, single phase brush lifting motors are ideal for installation on reciprocating pumps, compressors and other hard-to-start equipment. They provide the power to start under load—even in very cold weather—without over-motoring the driven machine.

Repulsion start motors provide greater starting torque per ampere of current than any other type of single phase motor—consequently the least disturbance to line voltage—an advantage on long or small capacity transmission lines.

Many power companies are recommending the use of single phase motors, up to 7½ HP, in residential districts of the larger cities, because polyphase energy is not always available. Century Type RS brush lifting motors are built in sizes from ½ to 20 HP—they are widely used in the farm areas which usually use only single phase energy.

Century builds a wide range of types of motors from 1/6 to 400 horsepower for all the popular electric power applications.

Century C Motors

582

Specify Century motors for all your electric power requirements.

Popular types and ratings are available from factory and branch office stocks.

CENTURY ELECTRIC COMPANY • 1806 Pine St., St. Louis 3, Missouri

Offices and Stock Points in Principal Cities

NEW CATALOGS

Stainless Steel Piping

A 4-page illustrated bulletin, No. 483, includes drawings, dimensions and prices of fittings and flanges available in stainless steel 304, 347, 316 and other materials.—*Taylor Forge & Pipe Works, P. O. Box 485, Chicago 90, Ill.* 153

Flexible Couplings

Bulletin 48, 24 pages, four colors, carries working data on the complete line of Ajax flexible couplings of forged steel and cast semi-steel construction.—*Ajax Flexible Coupling Co., Inc., Westfield, N. Y.* 154

Refrigeration Coil Selection Charts

A series of new "Selectomatic" charts are said to simplify coil selection for refrigeration applications by providing a quick method of determining proper balance of high side to low side apparatus. All normal ranges of refrigeration are covered.—*Marlo Coil Co., 6135 Manchester Ave., St. Louis 10, Mo.* 155

Air Diffuser

A 6-page bulletin covers the new square or rectangular Agitair "RTC" air diffuser, especially designed for use in acuostical ceilings. Diffusers are made in modular sizes to conform with standard tile dimensions. Sizes, patterns, and typical installations are shown.—*Air Devices, Inc., Dept. RTC, 17 E. 42nd St., New York 17, N. Y.* 156

Liquid Level Recorder

The Yarway remote liquid level recorder is covered in an 8-page bulletin. Construction details, and typical installations are illustrated.—*Yarnall-Waring Co., Chestnut Hill, Philadelphia 18, Pa.* 157

Blowers, Fans, and Exhausters

Under the title "Lungs for Industry," a 16-page, two-color bulletin describes centrifugal blowers and exhausters, roof ventilators, axial flow fans and rotary positive blowers. Photographs illustrate manufacturing and testing techniques and typical installations.—*General Blower Co., Morton Grove, Ill.* 158

Tachometers

Bulletin No. 103 describes electric hand tachometers and accessories with data on ranges, prices, and typical applications.—*Metron Instrument Co., 432 Lincoln St., Denver 9, Colo.* 159

Water Heating

A 16-page booklet, "Water Heating with L. P. Gas," gives installation economy tips and includes water consumption and sizing charts.—*Bryant Heater Co., Room 321, Plymouth Bldg., East 22nd St. and Prospect Ave., Cleveland 15, Ohio.* 160

Vaporizing Steam Heating

Bulletin No. 116 covers the Gorton system of vaporizing and equalizing existing steam heating systems for automatic heating. Installation procedures and special radiator valves are described.—*Gorton Heating Corp., Cranford, N. J.* 161

Refractory Enclosures

Bulletin 748 discusses problems encountered in designing air tight refractory enclosures for water walled boilers and shows how these problems are met by the Reintjes floating wall.—*George P. Reintjes Co., 2517-19 Jefferson St., Kansas City, Mo.* 162

Wagner Review

"This Is Wagner," a special edition of Wagner Electric's house organ, *Wagner Circle*, tells the story of the company as it is today, following its most successful year in its 57-year history. Photographs of company personnel and activities are included.—*Wagner Electric Corporation, 6400 Plymouth Avenue, St. Louis 14, Mo.* 163

Unit Heater Maintenance Chart

A unit heater maintenance chart lists vital points to check on the motors, condensers, and casings of unit heaters. The chart, measuring $9\frac{1}{8}$ x 12 in. and printed in red and black, is punched at the top to permit hanging from the wall as a reminder of points to be covered during unit heater inspection. *Modine Manufacturing Company, Racine, Wis.* 164

Scotch Boilers

Oil, gas, stoker, or hand-fired scotch boilers, are described in a 4-page bulletin covering the Series 4000 high pressure waterback type for heating, power or process. Includes dimension and capacity tables.—*Johnston Brothers, Inc., Ferrysburg, Mich.* 165

Industrial Insulations

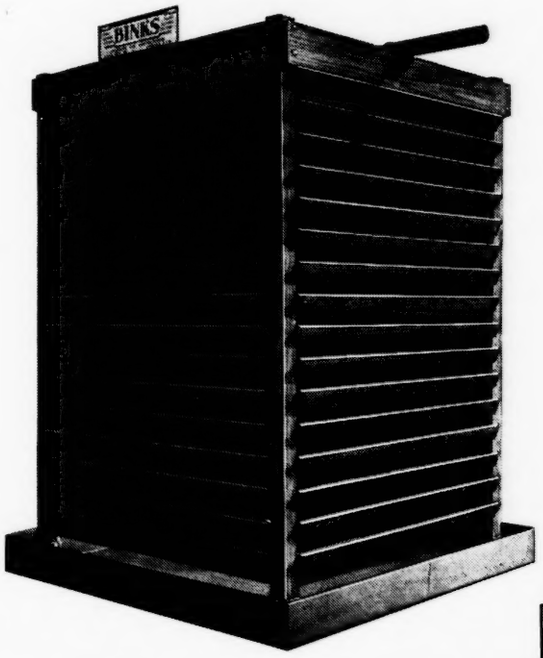
A 24-page catalog covers high temperature industrial insulations with charts and illustrations on the conductivity and installation of both plastic and block insulations offered by the company.—*Forty-eight Insulations, Inc., Aurora, Ill.* 166

Valve Packing

A new catalog section 12-R describes heat resisting molded valve packing. Packings are produced specifically for Edward cast and forged steel valves. Specifications and prices are included.—*Edward Valves, Inc., East Chicago, Ind.* 167

Evaporative Coolers

Series WCZ evaporative coolers in five sizes with capacities ranging from 5500 to 73,000 Btu per minute and with air quantities ranging from 2000 to 12,000 cfm, are described with accessories, specifications, and sizing data in Bulletin C-1100-B27A.—*Air Conditioning & Refrigeration Div., Worthington Pump and Machinery Corp., Harrison, N. J.* 168



BINKS

ALL REDWOOD PIPE "WS" NATURAL DRAFT COOLING TOWER

Binks Type "WS" Redwood Cooling Towers will provide efficient, trouble-free service on any industrial application. Ready for shipment in 30 standard sizes, ranging from 10 to 1200 GPM.

The product of expert engineering and workmanship throughout, Binks Type "WS" Redwood Towers are prefabricated for easy field assembly by ordinary labor without skilled factory supervision. Recommended for cooling condenser circulating water from refrigeration and air conditioning compressors, water-jacketed machinery, and wherever cooling of water or other liquids is required.

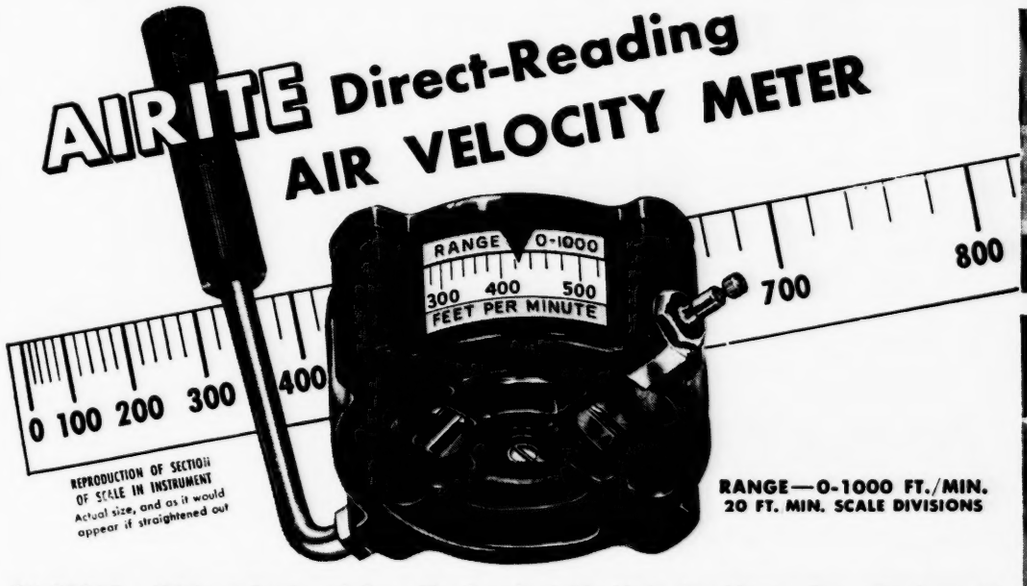
Send now for Bulletin No. 40, **giving full information on sizes, specifications and capacities of Binks Type "WS" Redwood Cooling Towers. State tower capacity required.**

THERE'S A BINKS TOWER FOR EVERY COOLING JOB

Binks MANUFACTURING COMPANY

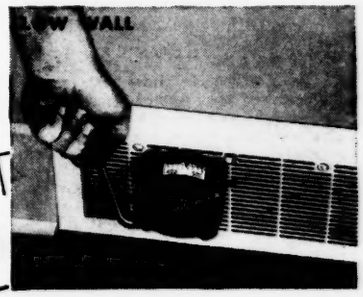
REPRESENTATIVES IN ALL PRINCIPAL CITIES ■ 3120-38 CARROLL AVENUE, CHICAGO, ILL.

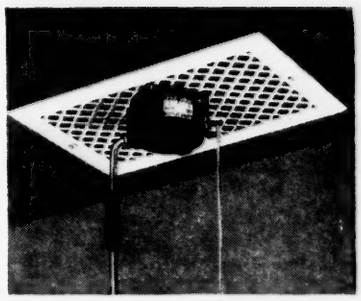
AIRITE Direct-Reading AIR VELOCITY METER



REPRODUCTION OF SECTION OF SCALE IN INSTRUMENT Actual size, and as it would appear if straightened out

RANGE—0-1000 FT./MIN.
20 FT. MIN. SCALE DIVISIONS





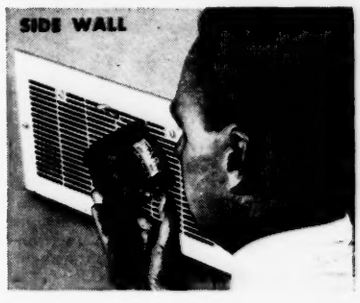
8" SCALE—Widest Scale of Any Mechanical Air Velocity Meter Ever Designed!

The AIRITE is an unsurpassed sales and service aid in heating, ventilating and air conditioning work. On installation and service work it is used to determine velocity and direction of air flow from registers and grilles for the purpose of checking rate of air delivery, balancing the system and adjusting deflecting vanes and louvers of registers so as to obtain "draft free" air distribution. These tests cut installation and service time, prevent expensive call-backs, and promote customer goodwill. The AIRITE is equally helpful for selling new equipment or modernization. It can be used in many ways to convincingly demonstrate discomforts and inefficiencies of a worn-out or inadequate system.

The AIRITE is entirely self-contained. It has no hose or probe, and gives all readings required for heating, ventilating and air conditioning work. The detachable handle facilitates use of the AIRITE at low wall or high side wall registers. By screwing a ⅛" pipe into the handle the AIRITE can be conveniently held against ceiling grille.

The AIRITE is equipped with a unique scale lock which makes it possible to retain the reading until the lock is released. For ceiling grille readings, this lock is easily manipulated by means of a piece of string. This feature makes the AIRITE exceptionally adaptable for indicating air velocity in hard-to-reach or dimly lit locations.

Dealer's Net Price *with leatherette carrying case* . . . **$19.80**



Ask your jobber for the AIRITE or write for Leaflet 749.

BACHARACH INDUSTRIAL INSTRUMENT CO. — 7000 Bennett Street · Pittsburgh 8, Pa.

Time Saver!

A handy "where-to-buy-it" directory that's needed by every Engineer and Contractor who specifies or buys equipment for HEATING, VENTILATING, AIR CONDITIONING, PIPING and REFRIGERATION systems.

Added feature – A LISTING OF MANUFACTURERS' LOCAL REPRESENTATIVES

1 PRODUCT Listing gives more than 900 types of equipment, accessory and material, shows who manufactures them.

2 MANUFACTURERS' Listing—alphabetical listing of firms manufacturing the foregoing products, with complete address.

3 TRADE NAME Listing gives current and obsolete trade names, tells type of product, gives manufacturer's name.

4 LOCAL REPRESENTATIVES' Listing gives Branch Offices and Sales Representatives of manufacturers — a real boon to buyers.

The BUYERS' DIRECTORY is a handy-size guide published annually by HEATING AND VENTILATING, listing the sources of supply for all types of products and materials used in Air Conditioning, Heating, Ventilating, Piping and Refrigeration. It is used by 10,000 Engineers and Contractors, tells them "who makes it" and "where to buy it." (See list of contents, left.)

The 1949 Directory (to be issued December, 1948) will contain a new section in which manufacturers list their Branch Offices and Local Representatives geographically with street address and telephone number. By referring to this list the Equipment Buyer can make prompt contact with his nearest representative, thus save much needless writing, wiring and phoning back and forth.

MANUFACTURERS! The advantages of having your advertisement in the 1949 BUYERS' DIRECTORY are obvious. For a full year your product story is at the fingertips of 10,000 Engineers and Contractors who specify and buy for installation in plants, office buildings, hospitals, hotels, stores, institutions, housing projects, etc. Advertising rates, distribution breakdown and other details gladly furnished. You can list your Local Representatives at $1.00 per name (name, address, telephone number). Ask for folder. HEATING AND VENTILATING, 148 Lafayette Street, New York 13, N. Y.

Suction Line Regulators

Suction line regulators are described in a new 20-page bulletin, No. 183. While primarily a catalog of Alco's line of evaporator pressure regulators, it contains sections on the proper selection, application, installation, adjustment and servicing of these devices. It includes descriptions of various remote pilots, both pressure and temperature types, some of them new to the industry, and of the regulators adapted to operation from an air control system as with various industrial instruments.—*Alco Valve Co., 865 Kingsland Ave., St. Louis 5, Mo.* 169

Heat Generators

Bulletin H-1 describes Cyclotherm heat generators of both steam and hot water types. The Cyclonic combustion system is illustrated with 2-color drawings. Tables cover standard ratings and dimensions of units from 10 to 300 boiler horsepower.—*Cyclotherm Corp., 75 West St., New York 6, N. Y.* 170

Heat Exchangers

Shell and tube heat exchangers and allied equipment are covered in a 2-color bulletin, illustrated with photographs and cut-away drawings and including data on design and construction and uses.—*Ross Heater & Mfg. Co., Inc., 1407 West Ave., Buffalo 13, N. Y.* 171

Flow Meters

Bulletin T-100-M describes ring balance flow meters and other instruments and offers capacity data for concentric orifices and flow nozzles. The bulletin also includes several specific graphs not previously published. A diagram covering recommended pressure tap spacing for flange, radius, and vena contracta taps and another diagram showing the permanent pressure loss to be expected from installation of the primary device are included.—*Hagan Corporation, 323 Fourth Ave., Pittsburgh 19, Pa.* 172

SEPTEMBER, 1948

TO OBTAIN COPIES OF TRADE LITERATURE listed in this issue, circle on the list below the publication wanted, using item number at the end of each review.

Print your name and address, mail to

Editor, HEATING AND VENTILATING,
148 Lafayette Street, New York 13, N. Y.

153	154	155	156	157
158	159	160	161	162
163	164	165	166	167
168	169	170	171	172

Name.....

Title (Must be shown).....

Firm (Must be shown).....

Business Address.....

City.....Zone....State.....9/48

WARM AIR FURNACES

(Concluded from page 110)

reported, that there would be a definite shortage of warm air furnaces later in 1948 unless additional supplies of raw materials were made available.

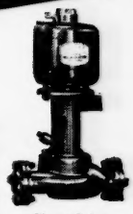
To help avert this shortage, the meeting recommended the appointment of an industry advisory committee, composed of representative warm air furnace producers, to develop a voluntary allocation agreement under Public Law 935. The Warm Air Furnace Industry Advisory Committee then appointed was later expanded to include manufacturers of furnace component parts and accessories (including registers and grilles, furnace blowers, and furnace pipe, fittings and ductwork) and the name of the committee changed to the Warm Air Heating Industry Advisory Committee.

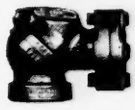
Consultation between the Committee, O.I.C., and other interested Government agencies resulted in the formulation of a voluntary program calling for the allocation of 233,000 tons of steel to producers of warm air heating equipment (including flue connected floor and wall furnaces designed for permanent installation) for the period from July 1, 1948 to February 28, 1949. Receipt of this quantity of steel products will, it is believed, help insure an output volume in keeping with the one million new housing unit program for 1948 and provide for essential replacements in existing dwelling units.

Agreement of the Steel Producers Advisory Committee to this program, signifying the steel industry's willingness to supply the tonnages of steel allocated, was given at meetings of this committee under O.I.C. auspices on May 20 and June 22. A public hearing on this program was held in accordance with the provisions of the authorizing statute and the agreement was approved by the Secretary of Commerce and by the Attorney General. Approval by these officials permitted the agreement to go into effect on July 1.

The agreement is purely voluntary in nature, and each participating warm air heating equipment producer is responsible for making his own contracts with his individual steel supplier for those quantities of steel allocated to him under the program. It will be up to the individual manufacturers to locate their own sources of supply; the Office of Industry Cooperation does not act as purchasing agent for any of the producers under the terms of the agreement—its function being limited to lending whatever assistance is required to the producing and consuming industries for the formulation of these voluntary agreements and assignment of quotas among participating companies. The allocations made are not a ceiling on the quantity of steel a manufacturer may receive if he is able to secure any additional tonnage outside of the program.

Another voluntary agreement now in process of preparation as this issue goes to press, is one that is designed to channel supplies of pig iron for castings to producers of a number of major cast iron building materials. Among the industries for which an allocation of pig iron is contemplated is the warm air furnace industry.


Direct Drive Circulators


Flow Control Valves

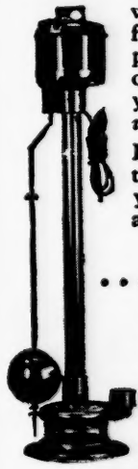
One-Pipe Distributors

Indirect Heaters

Triplex dealers are fortunate. Whether the jobs at hand are conversions in old homes or new home installations, these men can sell *unvarying comfort* that results from *hot water heating at its best!* Here are the reasons why:

The advanced design and precision construction of all Triplex Flow Control Units assure the most efficient, dependable operation possible. Hot water is automatically circulated, abundant heat supplied to radiators instantly . . . whenever and wherever needed. Third floor north is just as comfortable as first floor south, for Triplex Units automatically balance heat loss with heat supply. Ample hot water for domestic use is also provided at practically no additional cost. In other words, the Triplex line enables you to talk and sell in terms of *hot water at its best!*

Learn more about Triplex Flow Control Units and what they can do for you. Write today for latest catalog and price sheet.



...SELL DRY BASEMENTS, TOO

Triplex Sump Pumps (centrifugal closed impeller type) are famous for trouble-free service. Easily installed. Movable float ball permits wide variation in sump depth. Specially tailored motor, with built-in float switch, operates automatically. *Available* in iron and steel or brass models.

Triplex

HEATING SPECIALTY CO., INC.
PERU, INDIANA

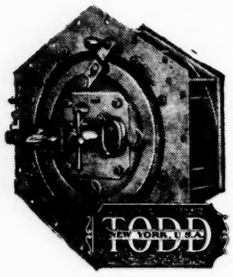
In addition to units illustrated, the Triplex line includes—Direct Drive Horizontal Circulators, Indirect Drive Circulators, Relief and Pressure Reducing Valves, Expansion Tanks, Air Eliminators, Water Mixing Valves, Air Vent Valves, Tankless Heaters, Control Units, Electrical Controls, Barometric Draft Dampers.

SEE YOUR WHOLESALER TODAY

THERE'S STILL TIME TO MODERNIZE YOUR BOILER PLANT WITH TODD BURNERS

You *can* replace obsolete equipment with Todd Burners and be ready for winter. The capacity of the Todd organization . . . world-wide distributors and facilities . . . standardized equipment . . . are your assurance of economy and efficiency in the burning of liquid and gaseous fuels. Take advantage of the long experience and "know how" of Todd engineers.

Oil Burners
Gas Burners
Combination Oil and Gas Burners



COMBUSTION EQUIPMENT DIVISION
TODD SHIPYARDS CORPORATION
81-16 45th Ave., Elmhurst, Queens, N. Y.

NEW YORK • BROOKLYN • ROCHESTER
BUFFALO • HOBOKEN • NEWARK • PHILADELPHIA
HARRISBURG • YORK • CHICAGO • CHARLESTON, S. C. • BOSTON • SPRINGFIELD, MASS.
BALTIMORE • WASHINGTON • RICHMOND, VA.
ATLANTA • DETROIT • GRAND RAPIDS • TAMPA
GALVESTON • HOUSTON • MOBILE • NEW ORLEANS • LOS ANGELES • SAN FRANCISCO
SEATTLE • MONTREAL • TORONTO
BARRANQUILLA • BUENOS AIRES • LONDON

. . . Since the Last Issue

Hobart C. McDaniel has been appointed manager, technical press service in the public relations department of **Westinghouse Electric Corp.**, Pittsburgh, Pa. Mr. McDaniel will be responsible for the company's publicity in the technical and trade magazines. He will succeed Carl E. Nagel who has resigned to join McGraw-Hill Book Company in New York as editor of mail sales books for the engineering and industrial fields. Mr. McDaniel was graduated in electrical engineering from Oregon State College, Corvallis, Ore., in 1926. He went with the Westinghouse Lamp Division in Bloomfield, N. J., as commercial engineer in 1939 after working with Pacific Power and Light Company, Portland, Ore., and Central Illinois Public Service Company, Springfield, Ill., as a lighting sales engineer. In 1943 he joined the technical press service in Pittsburgh.

American Air Filter Co., Inc., Louisville, Ky., announces the transfer of **James W. May** from Director of Research to Technical Director of its Air Filter Division. Prior to joining American Air Filter in 1943, he was associate professor of heating, ventilating and air conditioning at the College of Engineering, University of Kentucky. While there, he conducted research projects dealing with heating, ventilation and air filtration and spent several summer vacations handling special assignments in the AAF research laboratory.

J. W. May

Stephen J. Daly, formerly special assistant to the director of advertising, E. I. duPont deNemours & Company, Inc., Wilmington, Delaware, has been named advertising manager of **Owens-Corning Fiberglas Corp.**, Toledo, Ohio. Mr. Daly has been associated with the advertising department of the duPont Company since 1935. During the past year he was president of Eastern Industrial Advertisers, the Philadelphia Chapter of the National Industrial Advertisers Association. As advertising manager of Owens-Corning Fiberglas Corp. Mr. Daly will manage the company's advertising activities under the direction of E. C. Ames, director of advertising.

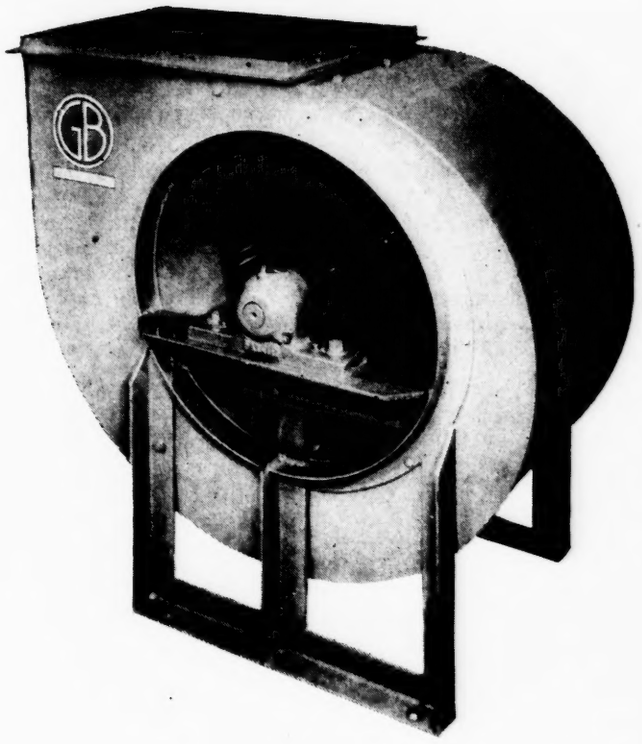
Ray R. West has been named manager of sales of **Minneapolis-Honeywell Regulator Co.** products for industrial applications. Mr. West, who has filled executive sales positions with Brown Instrument Co. during his more than 20 years with the industrial division of Honeywell, will make his headquarters at the Brown plant in Philadelphia. **Lloyd E. Slater** has been apppointed industry engineer in charge of food industry applications for measuring and control'ing devices, made by Brown Instrument Co. and Minneapolis-Honeywell Regulator Co.

F. E. Lehman, manager of the sales and service department of Aeroproducts division of **General Motors**, has been named assistant commercial sales manager of Frigidaire division. Mr. Lehman succeeds **A. C. Freimann**, who has been appointed general sales manager of Delco Appliance division, GMC.

United States Rubber Co. has named the **Graybar Electric Co.** exclusive distributor for Uskon conductive rubber panels used in the radiant heating of homes by electricity. The company, with offices in 103 cities, will handle the distribution of the panels through electrical contractors.

Appointment of **Waldo W. Schram** as assistant marketing director of the water heater division of the **A. O. Smith Corp.**, Kankakee, Ill., has been announced.

★ VENTILATING FANS



GB Fans — *manufactured for*

- Industrial and Commercial Ventilating and Heating
- Fume Extraction
- Forced Draft
- Induced Draft
- Air-conditioning
- Drying and Processing

— are of forward or backward curved wheel design.

TYPE F. C. are designed for quiet operation at low speeds. TYPE B. C. are designed to operate at high speeds and have the non-overloading characteristics.

Capacities of 200 c.f.m. to 300,000 c.f.m. are covered by standard sizes and arrangements.

The heavier constructions of classes II, III and IV cover the particular needs of special applications.

Send for Bulletin SC-103

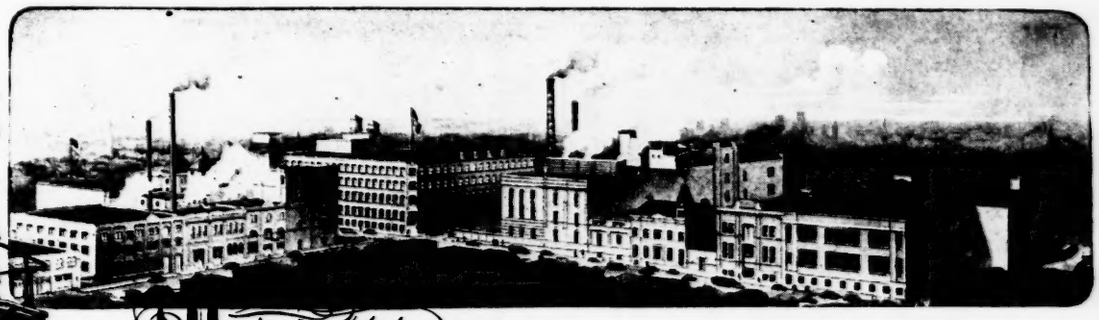
"LUNGS FOR INDUSTRY"

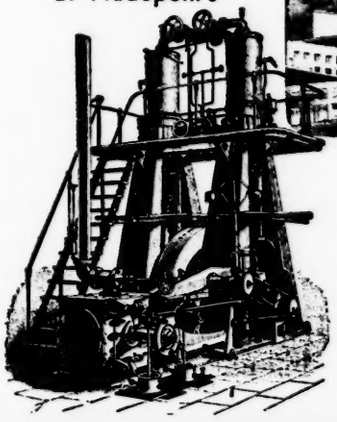
GENERAL BLOWER CO.

8622 FERRIS AVE. MORTON GROVE 13, ILL.

• Engineering Offices in All Principal Cities

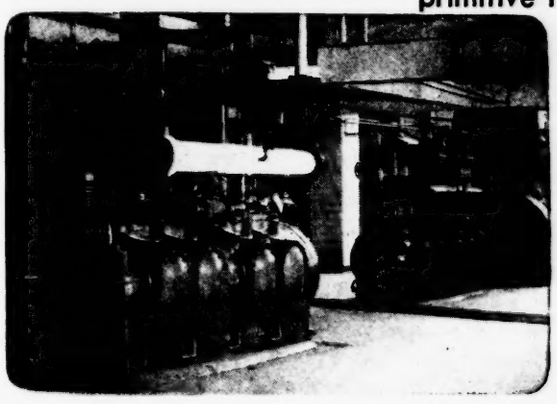
Below: Old and New Types of Frick Machines at Hudepohl's





Hudepohl Breweries Use FRICK Refrigeration 60 Years!

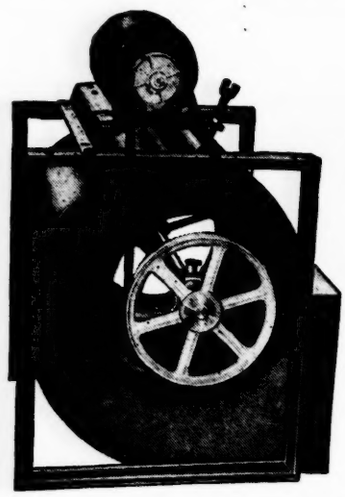
Frick ammonia compressors, as built in the Eighties and Nineties, were primitive machines by today's standards. But they were remarkably dependable: one of those installed in the Hudepohl Breweries at Cincinnati ran 57 years, another 52, two others 45!



Naturally, Hudepohls believe in Frick Refrigeration. Their fine new engine room contains the two big Frick 4-cylinder machines illustrated.

You'll get the last word in reliability when you specify Frick Refrigeration.

FRICK COMPANY Waynesboro, Penna.



THE

NEW

UNIVERSAL

TYPE "N"

BLOWER

MASSACHUSETTS . .

By changing the position of the oil cup, the four popular discharges (lower horizontal, upper horizontal, down-blast and up-blast) can be obtained. Sizes 7 to 16½ inches wheel diameter.

WRITE FOR BULLETIN No. 110 CATALOG

MASSACHUSETTS BLOWER DIVISION

The BISHOP & BABCOCK Mfg. Co.

4901 HAMILTON AVENUE · CLEVELAND 14, OHIO

MERCOID

A SYMBOL OF DEPENDABILITY IN AUTOMATIC CONTROLS

MERCOID NOISELESS RELAYS

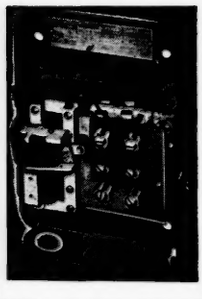
Are Mercury Switch Types — Exclusive in Design and Operation

Noise always has been and always will be an objectionable nuisance wherever encountered. Much study is given to its elimination. "Quiet Operation" is one of the keynote objectives in the realm of mechanical creations.

A postwar public will expect less noise on all operating equipment. If you are looking for better ways of serving the automatic heating trade, Mercoid offers a definite solution to the noisy relay problem. It is a worthwhile talking feature. In addition, Mercoid Relays are not only quiet, but they assure more dependable performance and longer control life, all of which are equally desirable.

These relays must not be confused with the conventional clapper type.

THE QUIET OPERATION OF THE MERCOID TRANSFORMER-RELAY MAKES IT IDEAL FOR ALL OIL BURNER AND STOKER RELAY REQUIREMENTS



THE MERCOID CORPORATION

4201 BELMONT AVENUE.

CHICAGO, ILL., U.S.A.

The Herman Nelson Corp., Moline, Ill., manufacturers of heating and ventilating products, announces the appointment of **James D. Hodges** as eastern divisional manager of the company's line of portable heaters and ventilators. For the past three years Mr. Hodges has been service manager of the portable products division.

Formation of a new department of the **Minneapolis-Honeywell Regulator Co.** to supervise and coordinate the advertising, merchandising and sales promotion activities of the company has been announced. **John R. Bergan** has been appointed head of the new department as merchandising manager. Other changes include the promotion of **Chandler Murphy** as advertising manager and **John A. Young** as sales promotion manager. Mr. Murphy succeeds William B. Walrath who has resigned to join the Chicago advertising staff of Fortune magazine.

C. Murphy

J. R. Bergan

J. A. Young

Mr. Bergan is a native of Racine, Wis., and an architectural engineering graduate of the University of Minnesota. He joined Honeywell in 1935. In 1944, he was named eastern regional sales manager for the company's Moduflow division, a position he held until his latest promotion as merchandising manager. He will move his headquarters from New York to the home office in Minneapolis. Mr. Young is a native of Ossining, N. Y., and attended Haverford College, the University of Minnesota and the Ecole du Montcel in Paris, where he specialized in architectural courses. Prior to joining Honeywell, he worked in the export department of Cargill, and until his latest promotion was serving as acting sales promotion manager. Mr. Murphy joined Honeywell in 1935 after serving as advertising and sales promotion manager for the Gray Company, Minneapolis. Since 1935 he has served in various capacities in Honeywell's sales promotion and advertising departments, and was convention and display manager until moving into his new position.

W. D. Reed announces the formation of the **Star Tubular Products Co.**, 4747 S. Richmond Street, Chicago, Ill. The new company has purchased the assets and facilities of the Star Nipple Co., same address, in Chicago. The new company will produce a complete line of pipe nipples and will also make pre-fabricated tubular products. Active charge of the company will be in the hands of Mr. Reed as president and **Richard L. Kopp** as secretary. Mr. Reed recently resigned as vice-president of The Sawhill Manufacturing Co., Sharon, Pa. Mr. Kopp has been assistant sales manager of The Sawhill Manufacturing Co.

The **Allen-Bradley Co.**, manufacturers of electric motor controls, Milwaukee, Wis., announce the removal of their Northern Ohio district office to 4312 Carnegie Avenue, Cleveland 3, Ohio.

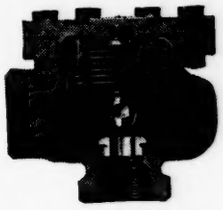
Johnson Service Co., Milwaukee, manufacturers of automatic temperature and air conditioning control systems has announced the opening of a branch office in Charlotte, North Carolina. The company now has 35 branches in the United States. **E. D. Streng**, formerly of the Greensboro, North Carolina branch, has been promoted to sales engineer in charge of the new branch.

NICHOLSON MAKES

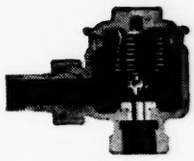
UNIT TRAPPING

Practical

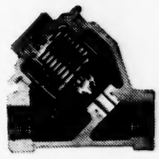
and Economical



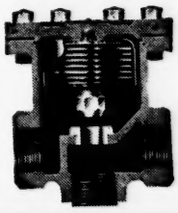
FASTER HEAT TRANSFER and LOWER FUEL COSTS are two of the immediate benefits of equipping each unit with its own trap. It's an ideal, efficiency-wise, that Nicholson is making possible in an increasing number of plants.



Nicholson steam traps make unit-trapping practical because: their low cost makes it economically possible; there is a Nicholson trap for every power, heat and process purpose; your Nicholson service engineer is experienced in planning a practical system.



Bulletin 1047 or see Sweet's



W. H. NICHOLSON & CO.

199 OREGON ST., WILKES-BARRE, PA.

Valves ★ Traps ★ Steam Specialties

COST SAVING

REZNOR

AUTOMATIC

Gas Fired Unit Heater

Automatic heating saves . . .

TIME—Sell time-saving and the pleasure of going to the office, shop, or factory without facing the delays and interruptions of heating problems. The Reznor gas fired unit "automatically" controls temperature without time-consuming attention.

EXPENSE—"No fireman," "no boilers," "no smoke and soot" are cost saving items that Reznor users enjoy. Reznor units extract the maximum heat from gas.

INSTALL REZNOR UNITS WITH THE BIG, QUIET FAN, NOW

Large or small commercial, industrial, and residential buildings enjoy the benefits of Reznor "automatic" heating.

REZNOR *Gas fired unit heaters*

SUSPENDED OR FLOOR MODEL

A SIZE FOR EVERY NEED

REZNOR CO. MERCER 9, PENNA.

GAS FIRED HEATERS SINCE 1888

NO BOILERS • NO STEAM LINES
NO FUEL STORAGE • NO FIRE TENDING

FOR

Quality Products
Prompt Service
Profitable Cooperation

Buy from a Herman Nelson Distributor like Careva Company of York, Pennsylvania.

E. G. Carpenter, President
Careva Company, York, Pa.

The Herman Nelson Corporation and its carefully selected Distributors like Careva Company have a nationwide reputation for prompt delivery of quality products. What's just as important — they're ready and anxious to help you with profitable merchandising cooperation.

Sales promotion campaigns and literature provided by Herman Nelson are boosting sales for dealers and contractors throughout the country.

Herman Nelson distributors meet your requirements promptly from stock for both equipment and installation materials.

Immediate service from Herman Nelson is available from members of the sales and engineering departments of its distributor organizations.

Increase your business by selling Herman Nelson quality products and benefit from prompt service and friendly cooperation. Contact the nearest Herman Nelson distributor for quality heating and ventilating equipment and the kind of cooperation and service that mean extra profits for your business.

Herman Nelson Vertical Shaft Propeller-Fan Type Unit Heaters
Part of Herman Nelson's
QUALITY LINE
of Heating and Ventilating Equipment
Herman Nelson Horizontal Shaft Propeller-Fan Type Unit Heaters

THE HERMAN NELSON CORPORATION

Since 1906 Manufacturers of Quality Heating and Ventilating Products

MOLINE, ILLINOIS

Self-Cleaning Feature of

DEPENDABLE
Water Regulating Valve

. . . MEANS
"TROUBLE-FREE"
ACCURACY AND
LONGER SERVICE

You'll avoid trouble—

due to dirt and lime in your water when you install the new A-P Model 68-B Water Regulating Valve on your water-cooled condensing units. This Valve, designed on a radically different operating principle, actually "cleans itself." A special molded composition seal on the valve stem slides across the polished mirror-smooth stainless steel seat providing an effective "wiping" action as it opens or closes the valve. This unique seal and seat shows no sign of wear after the equivalent of many years use—proof of a "lifetime" of accurate water regulating service.

With an operating head pressure of 50 to 150 p.s.i. Model 68-B can be easily adjusted to your system through the wide port in the body. Its long stroke provides closer, more uniform control without chattering or water-hammer. Three sizes, ⅜", ½" and ¾" inlet and outlet, offer a wide range of utility on Freon, Methyl Chloride or Sulphur Dioxide systems. Buy it today at your leading Refrigeration Jobbers — or write for bulletin No. M100.

DEPENDABLE Refrigeration Valves include: Thermostatic Expansion Valves, Refrigerant and Water Solenoids, Suction Pressure Regulating Valves, "Trap-Dri" Drier-Filter-Strainer and "Trap-It" Filter-Strainer, and Thermostats for cooling or heating.

AUTOMATIC PRODUCTS COMPANY

2462 North Thirty-Second St., Milwaukee 10, Wisconsin
Export Dept., 13 East 40th Street, New York 16, N. Y.

DEPENDABLE
REFRIGERANT VALVES
FOR AIR CONDITIONING • REFRIGERATION • HEATING

R-904

A. C. Monteith, 46-year-old engineering executive of the **Westinghouse Electric Corp.,** has been elected vice-president in charge of engineering and research. He succeeds Marvin W. Smith whose election as executive vice-president of Baldwin Locomotive Works was announced. Mr. Monteith was born in Brucefield, Ontario, in 1902, and is now a naturalized U. S. citizen. He was graduated from Queens University at Kingston, Ontario, with the Bachelor of Science degree in electrical engineering in 1923. Mr. Montieth joined Westinghouse in 1923 as a graduate student engineer in the training course, and was assigned to the central station engineering department in 1924. He became manager of that department in 1938 and in 1941 was named manager of the industry engineering department. In 1945, he took over the dual position of manager of headquarters engineering departments and director of education.

United States Radiator Corp. has announced that **Howard B. Steggall,** vice-president in charge of the company's Pacific Steel Boiler Division, has been elected a director of the corporation, replacing on the board Carroll M. Baumgardner, who has resigned as director and executive vice-president.

Bryant Heater Co. has appointed **Karl W. Schick** distributor for Dallas, Texas. Located at 1123 N. Haskell Ave., Dallas, Texas, Mr. Schick will maintain a complete line of Bryant gas heating equipment.

Dravo Corp. has completed transfer of its city offices from the Dravo Building at 300 Penn Avenue to the former Pitt Bank Building, Fifth and Liberty Avenues, purchased by the corporation last year. The 12-story building, one of Pittsburgh's first "skyscrapers," has been renamed Dravo Building.

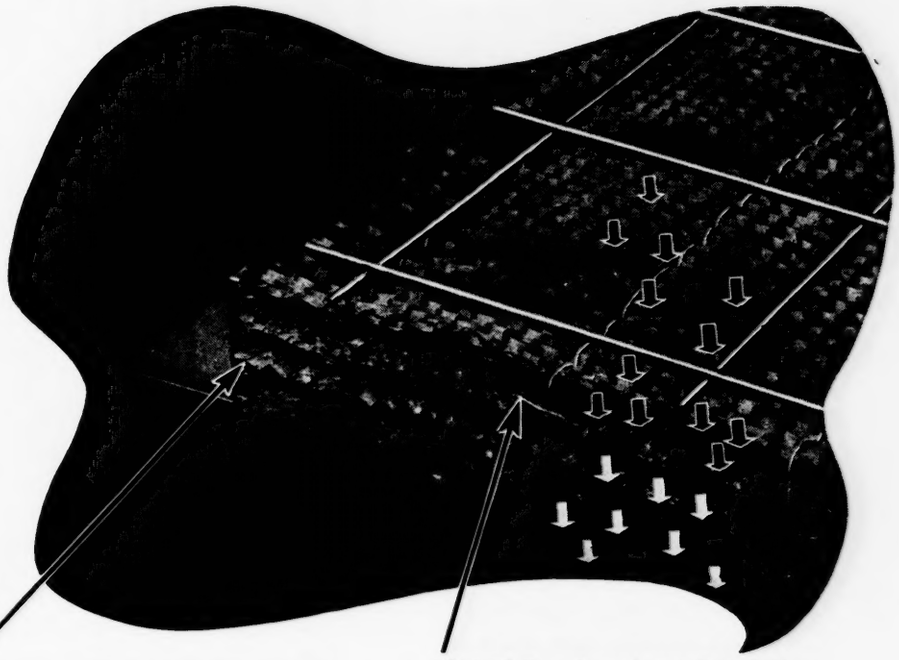
John H. Bartol, formerly passenger sales supervisor, American Air Lines, has joined the **W. B. Connor Engineering Corp.,** manufacturers of Dorex air purification equipment and Kno-Draft adjustable air diffusers, as director of the air recovery division.

E. A. Price has been appointed manager of the New York district office for **Penn Electric Switch Co.** He succeeds N. E. Jennison who resigned to enter the wholesale refrigeration business. Mr. Price was formerly manager of the company's Dayton, Ohio and Dallas, Texas districts.

A western sales division with headquarters at Pasadena, Cal., has been established by **The Schaible Co.,** designers and manufacturers of fittings and valves for the plumbing and heating industries. This new division will provide immediate deliveries in 10 Pacific coast and Rocky Mountain states and Pacific overseas markets.

William Penrose Whittington, president of **Whittington Pump and Engineering Corp.,** died June 30 following a brief illness. He was born in Mt. Vernon, Ohio in 1887 and moved to Indianapolis in 1921. He was self-educated, a thinker, an inventor, and he had natural musical ability, both voice and instrumental. He invented and patented in about 1926 a vacuum heating pump and has manufactured this pump since that time. He was well known in the heating and pumping industry and his knowledge and ability in the industry was highly respected by friends and associates. The Whittington Pump and Engineering Corporation will carry on as before under the direction of his son, Dick W. Whittington, who was fortunate to have had the opportunity to work under his father's direction since 1932 with the exception of four years engineering experience with another firm.

IN AIR FILTERING THE *Self-Seal Edge* MAKES A DIFFERENCE



The Research Self-Seal Air Filter is built slightly over size, and fits snugly into the holding frame with a self-sealing edge that absolutely prevents any bypass of unfiltered air.

All circulating air must pass through the filter media, where thousands of tiny baffles cause a turbulent action in the air stream, and effectively scrub out dirt, dust, lint and pollen.

RESEARCH *Self-Seal* AIR FILTERS

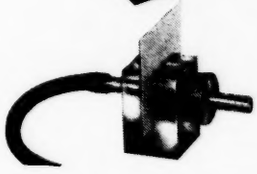
MANUFACTURED BY **RESEARCH PRODUCTS CORP., MADISON 10, WISCONSIN**

WATCH YOUR SMOKE!

with

DWYER TRANSPARENT

SMOKE GAGE



KNOW what your burner or furnace is doing—BE SURE you are getting the maximum amount of CO_2 with clean combustion. The DWYER Smoke Gage gives you an actual sample of smoke for comparison with the DWYER Smoke Chart. For greater fuel saving efficiency with soot-free burning, it's the DWYER Smoke Gage . . . . precision-made, accurate, inexpensive!

DWYER No. 910 Smoke Gage . . $8.50 Complete

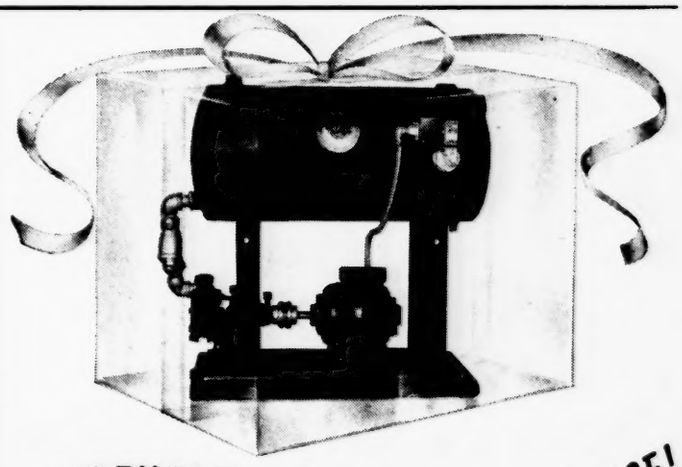
(DWYER 910-S Smoke Gage, for use with DWYER Combustion Test Set, no duplication of parts . . . . $4.50)

HOW TO USE IT: With Smoke Gage terminal tube in smoke pipe opening, force smoke sample through paper in Gage holder with aspirator bulb. Remove paper and compare with Chart. It's that easy!

Write for literature describing the complete line of DWYER Test Instruments—Manometers, Draft Gages, etc.

F. W. Dwyer Mfg. Co.

309 SOUTH WESTERN AVENUE, CHICAGO 12, ILLINOIS



CONDENSATE RETURN IN A PACKAGE!

Roth Condensate Return Units are engineered for long and efficient service—packaged for easy installation in a minimum of space. Equipped with the Roth Turbine Type Pump which develops high pressures, handles hot condensate without vapor binding and operates economically.

Capacities—up to 17,000 sq. ft. E.D.R.

Pressures—up to 100 lbs.

Easily installed—just connect piping and plug in.

Packaged—complete with pump, receiver, motor, automatic float switch, strainer, piping, base.

Write for catalog No. 2.

Turbine type pumps for air conditioning units in stock.

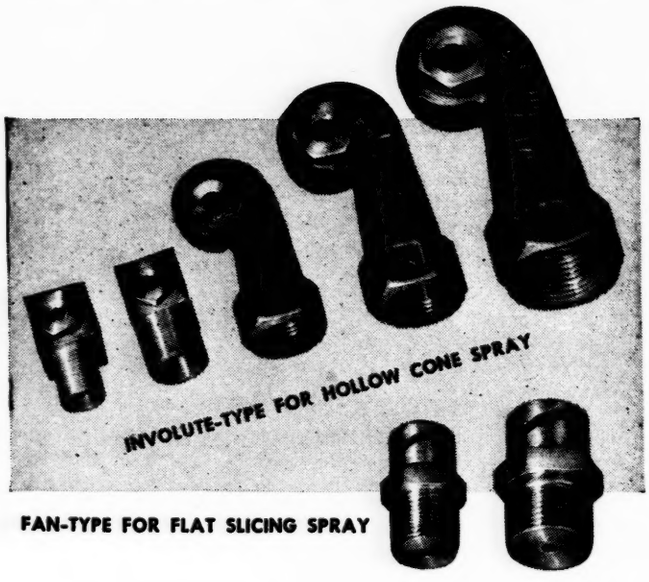
Roy E. Roth Company, 2436 Fourth Ave., Rock Island, Ill.

ROTH PUMPS

for • SPRAYING
• WASHING
• RINSING
• COOLING
• AIR CONDITIONING

YARWAY

SPRAY NOZZLES



FAN-TYPE FOR FLAT SLICING SPRAY

Get the most out of your Spraying Equipment with minimum power . . . with efficient spraying.

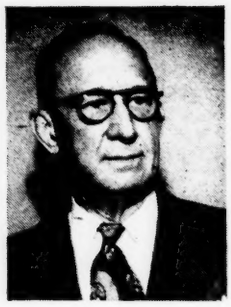
Use Yarway Nozzles. No internal vanes or other restrictions to clog or hinder flow. Two types—Yarway Involute-type producing a fine hollow spray with minimum energy loss, and Yarway Fan-type producing a flat fan-shaped spray with time-saving slicing action for cleaning.

Wide range of standard sizes and capacities. Cast or machined from solid bar stock.

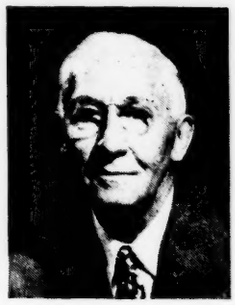
Thousands in use. - - Write for Bulletin N-616.

YARNALL-WARING COMPANY
104 Mermaid Avenue Philadelphia 18, Pa.

Frank S. Kaulback, vice-president and general manager of branches of the **American Radiator & Standard Sanitary Corp.,** is retiring from active service on the company's retirement plan. Mr. Kaulback will be succeeded by **Robert W. Lang,** supervisor of the central division of the American-Standard Branch House Department, who has



R. W. Lang



F. S. Kaulback

been elected vice-president and general manager of branches. Mr. Kaulback, who has been in his present post since 1930, has been associated with American-Standard for the past 45 years, beginning his career as a showroom attendent. He is a director and a member of the executive committee of the corporation, as well as an officer and director of several of its subsidiary companies. He will continue to serve as a director and as a member of the executive committee. Mr. Lang is a native of Toledo. He joined the Standard Sanitary Manufacturing Co., a predecessor company of American-Standard, in Toledo in 1914, beginning as a salesman and rising to manager of the Toledo branch. He was further promoted to managing supervisor of the central division in 1934, and, two years later, was advanced to the position he held up to the time of his present promotion. Mr. Lang will make his headquarters in Pittsburgh.

James D. Burnes has been elected vice-president and general manager of **Petroleum Heat and Power Co. Thomas J. Cody** succeeds Mr. Burnes as treasurer. Mr. Burnes has been treasurer of Petro since 1945, and was elected a vice-president in 1947. His service with the company began in 1928, following his graduation from Villanova, and his activities from then until 1945 included various phases of branch and home office accounting and administrative work. Mr. Cody was Petro's comptroller since early in 1947. He joined the Petro organization in 1931 after graduation from Columbia, where he majored in accounting, and was assigned to various branch offices during his earlier years with Petro. More recently he headed the Tax and Insurance Department in the home office of the company.

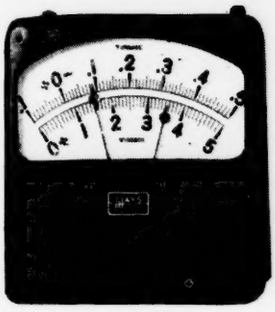
V. Dale Wissmiller has been named supervisor of national accounts and refrigeration for the commercial controls division of the **Minneapolis-Honeywell Regular Co.** Mr. Wissmiller has been western division manager of the transportation division, working out of Chicago.

Robert M. Vilsack has joined the sales department of **Taylor Forge & Pipe Works,** reporting to the main plant at Chicago, Ill. Mr. Vilsack was recently associated with the M. W. Kellogg Co. of New York in engineering and sales work.

George E. Athana has rejoined **York-Shipley, Inc.,** as sales manager of the New York territory. Mr. Athana was with York-Heat for 3 years prior to the war as New England district manager and during the war was assistant to the president.

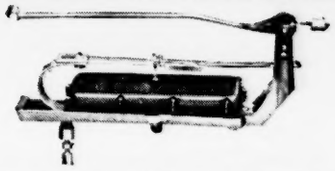
Pacific Engineering Equipment Co., exclusive western distributors for **Cyclotherm Corp.,** announces the establishment of its principal office at 1217 S. W. 19th Ave., Portland 5, Ore.

DRAFT GAGES



. . . that are

MECHANICALLY SIMPLE— lastingly accurate



The fine accuracy, durability and dependability of Hays Draft Gages stem from the unique colon leather diaphragm. Remarkably tough, yet soft and pliable, it withstands constant flexing, lasts indefinitely, maintains extreme sensitivity and accuracy and is unaffected by sudden overloads. Complete range of sizes for every need. Write for Bulletin 47-667.

The HAYS CORPORATION
COMBUSTION & INDUSTRIAL INSTRUMENTS & CONTROL
MICHIGAN CITY, INDIANA, U.S.A.

BETTER
Flexible
METAL HOSE
FOR EVERY PURPOSE

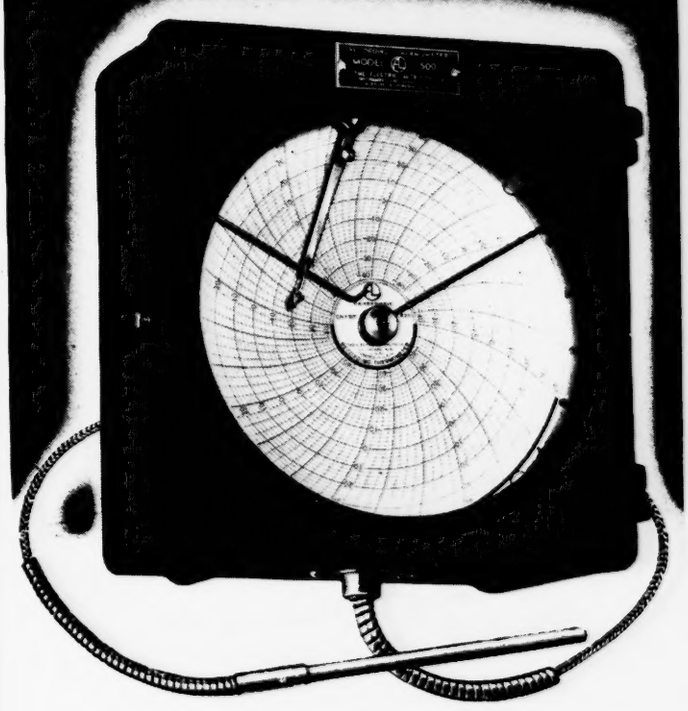
• **SEAMLESS**—Constructed from one continuous piece of uniform thickness • **PARALLEL CORRUGATION** assures maximum strength and flexibility • **SPECIAL ALLOYS** provide resistance to heat, acid, etc., depending on requirements • **AVAILABLE** in wide variety of types to convey all kinds of liquids and gases • **AVAILABLE** in complete form as vibration reducers for Air Conditioning and Refrigeration Units.

Write Eclipse-Pioneer for information.

ECLIPSE-PIONEER Division of Bendix AVIATION CORPORATION
TETERBORO, NEW JERSEY

Depend on

AUTO-LITE



Model "500" is equipped with capillary tubing for remote reading. Priced from $37.50

THIS Auto-Lite Recording Thermometer is designed for utmost efficiency and dependability. Its vigilant recording of continuous operating cycles furnishes money-saving proof of temperature behavior. 6-inch chart with sub-divisions uniformly spaced. Model "500" Recording Thermometer is not affected by altitude or by the temperature of the room in which it is located. All readings represent true temperatures at the point where the bulb is inserted. Write for illustrated catalog describing the Recorder and other styles and types of Auto-Lite thermometers.

THE ELECTRIC AUTO-LITE COMPANY
INSTRUMENT AND GAUGE DIVISION • TOLEDO 1, OHIO
NEW YORK CHICAGO SARNIA, ONTARIO

INDICATING & RECORDING
THERMOMETERS

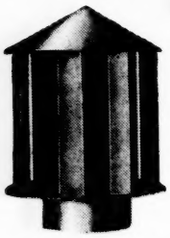
ON CHIMNEYS AND VENT FLUES

Breidert Air-X-Hausters

(PAT. NO. 2269428)

Breidert Air-X-Hauster Chimney Top makes fireplace draw better.

the first scientific improvement in roof ventilators in over 50 years!



Type B Breidert Air-X-Hauster for factories, commercial and residential buildings.

No matter which way the wind blows, no matter how bad the weather—the Breidert *provides positive exhaust.* Designed in accordance with the science of aerodynamics, this revolutionary ventilator utilizes the power of air currents coming from *all angles* to provide safe, positive ventilation without back-draft. Stationary—no moving parts to regulate or get out of order... no power consumption... compact and pleasing in appearance.

Breidert Air-X-Hauster—the first ventilator to be tested under all variable vertical and horizontal wind conditions... with certified ratings published.

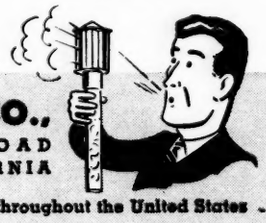
Unlike most conventional ventilators which work efficiently only when wind strikes in a horizontal plane, the Breidert has been thoroughly tested—by U. S. Navy and Smith Emery Commercial Testing Laboratories—with the wind blowing in *all* directions. Its remarkably high performance ratings under all conditions are *certified and published.*

Many Thousands in Use all over the Country

Breidert Air-X-Hausters have found wide acceptance among architects, engineers, industrialists, farmers, home owners, ship and boat owners, U. S. Army, U. S. Navy, Maritime Commission, schools, institutions and public buildings. In every case when properly installed, the Breidert has never failed to fully meet every claim made for it!

Free Engineering Data Book, with complete specifications, sent on request. Address

"Ask to see this interesting demonstration"



G. C. BREIDERT CO.,
3129 SAN FERNANDO ROAD
LOS ANGELES 41, CALIFORNIA

Representatives in 50 principal cities throughout the United States

The **Fedders-Quigan Corp.** of Buffalo, N. Y., announces the appointment of the **L. & P. Electric Co.,** 684 Bedford Ave., Brooklyn, N. Y., as exclusive distributor for Fedders room air conditioners in New York, Brooklyn, Queens, The Bronx, Westchester, Nassau and Suffolk counties. The L. & P. Electric Co. succeeds the D. W. May Co. whose Fedders distributorship will now be concentrated in New Jersey.

The appointment of **B. H. Cox,** former sales promotion manager of Frigidaire's St. Louis branch, to advertising and sales promotion manager of the Chicago branch of the **Frigidaire Sales Corp.** has been announced.

The **Tennessee Heating Sales Co.,** Knoxville, has just been appointed distributor for **Dravo** "Counterflo" heaters in Tennessee, east of the Tennessee River; Southeast Kentucky; Southwest Virginia, and North Carolina, west of Asheville.

Getting Personal

F. P. Bleier

Frank P. Bleier *(Design, Performance, and Selection of Centrifugal Fans,* page 67) is an industrial physicist and widely known designer of air moving equipment. Since 1946 he has served as technical consultant to manufacturers whose lines include fans, blowers or compressors, either as self-contained units or as built-in parts of other machinery. Prior to establishing his own consulting offices in Chicago, Mr. Bleier was director of research and development of the Ilg Electric Ventilating Co., Chicago. Before that, he was connected with the DeBothezat Fan Co., East Moline, Illinois and with the Societe Lyonnaise de Ventilation Industrielle, France. He is a graduate of the Technical University of Vienna, Austria, in applied mechanics and aerodynamics and has published many technical papers in the field of fan and blower design.

A. G. Canar

Alford G. Canar *(Does Oil and Gas Heating Demand Extra Radiator Surface?,* page 65) graduated in 1916 from the University of Wisconsin with a degree in chemical engineering. His first experience prior to World War I was in operation of coal tar distillation plants. After the war he worked on development and research in low temperature carbonization of Colorado coal and oil shale. He says he is probably one of the first who ever drove a motor car powered with fuel obtained by himself from low temperature carbonization. After further experience in oil and powdered coal distillation processes, he began, in 1925, a career in sales and engineering research of gas fired central heating plants. Out of this experience a series of articles were published in 1936 to 1940 on engineering gas conversion burner installations. He installed the first complete summer air conditioning job in Chicago in 1931 where both temperature and humidity were under close control. Another such installation was made in the Illinois University Research Hospital where hay fever

Announcing

TAL Portable Tube Bender *for radiant heating*

Bend right on the spot, fast and accurately

Now, with this new light-weight machine that can be carried in one hand, you can speed-up radiant heating installations . . . for the Tal Tube Bender handles, without annealing, *hard copper* tubing as well as soft, both K and L, in all diameters from 3/8" to 1" in all standard radii. Changeovers from one size to another can be made in 40 seconds. One man does everything without help. No flattening, no kinks, no wrinkles. Made and guaranteed by Tal, the world's largest exclusive producer of pipe and tube bending equipment. Write today for data bulletin.

Tal Bender, Inc. Dept. 12 Milwaukee 2, Wis.

AUER GRILLES

Many designs for all purposes—air conditioning, ventilating, radiator enclosure and concealment. Almost any sizes in steel, aluminum, brass or bronze. In selecting grilles, you will find Auer Grille Catalog "G" useful. It gives complete grille data, shows all Auer designs, with dimensions, opening sizes, and full scale details. Sent on request. Order Auer Grilles by name and number.

THE AUER REGISTER COMPANY
3608 PAYNE AVE. CLEVELAND 14, OHIO

HEATING AND VENTILATING
Handy Reference Series

Single-subject booklets featuring concise information for the heating and air conditioning engineer and contractor. Paper bound, $1.00 each.

LAW OF CONTRACTS SIMPLIFIED—Heating, ventilating and air conditioning cases involving higher court decisions analyzed to clarify the law of contracts, chattel mortgages and real estate law, legal status of independent contractors and patent law. In non-legal language, for contractors and engineers.

EXHAUST HOODS—How to design for efficient removal of dust, fumes, vapors and gases, with data, formulas and practical examples showing exact procedure.

FLUID FLOW IN PIPING—A simple and concise summary of the fundamentals of fluid flow theory and practice with application of these basic data to practical problems of steam, water and air piping.

THE INDUSTRIAL PRESS,
148 Lafayette Street, New York 13, N. Y.

"Z"crete

THE MODERN LOW COST UNDERGROUND INSULATING SYSTEM... No Critical Materials Needed

This modern streamline insulation is readily available from conveniently located authorized applicators. For design data, samples or other information contact one of the following representatives:

1. Asbestos Supply Co. of Seattle, 321 First St., Seattle, Wash.
2. Asbestos Supply Co. of Tacoma, 1926 Pacific Ave., Tacoma, Wash.
3. Asbestos Supply Co. of Oregon, 221 S. W. Front St., Portland, Ore.
4. Northwest Insulations Co., 1318 N. Maple St., Spokane, Wash.
5. Dutton Asbestos & Supply Co., 532 Natoma St., San Francisco, Cal.
6. J. T. Thorpe, Inc., 948 E. Second St., Los Angeles, Cal.
7. Utah Pioneer Corp., 333 W. First St. S., Salt Lake City, Utah
8. Walker-Jamar Co., 365 S. First Ave. E, Duluth, Minn.
9. G. A. MacArthur Co., 2387 Hampden Ave., St. Paul, Minn.
10. Central Asbestos & Supply Co., 317 E. Sixth Ave., Des Moines, Iowa
11. Midwest Z-Crete Co., 512 Grain Exchange Bldg., Omaha, Neb.
12. Standard Asbestos Mfg. & Insulating Co., 410 Olive Dr. North, Kansas City, Mo.
13. Standard Asbestos Mfg. & Insulating Co., 5601 Clinton Dr., Houston, Tex.
14. Standard Asbestos Mfg. & Insulating Co., P. O. Box 446, Baton Rouge, La.
15. Standard Asbestos Mfg. & Insulating Co., 825 S. W. Fifth St., Oklahoma City, Okla.
16. Victor H. Wilson Co., Union Bus Terminal Bldg., Nashville, Tenn.
17. Conduit Contracting Co., 2317 Tennessee Ave., St. Louis, Mo.
18. R. E. Kramig & Co., 222 E. Fourteenth St., Cincinnati, Ohio
19. Midland Engineering Co., 1604 DeLoss St., Indianapolis, Ind.
20. Midland Engineering Co., 1314 Calhoun St., Fort Wayne, Ind.
21. Midland Engineering Co., 401 S. Notre Dame St., South Bend, Ind.
22. Luse-Stevenson Co., 873 W. Blackhawk St., Chicago, Ill.
23. Sprinkmann Sons Construction, Ltd., 418 N. Second St., Milwaukee, Wis.
24. Murphy Supply Co., 320 N. Capital Ave., Lansing, Mich.
25. R. H. McManus & Co., 16100 W. Eight Mile Rd., Detroit, Mich.
26. Clark Asbestos Co., 1893 E. 55th St., Cleveland, Ohio
27. U. S. Heat & Frost Insulation Co., 824 Hertel Ave., Buffalo, N. Y.
28. Industrial Insulations, Inc., 311 E. Carson St., Pittsburgh, Pa.
29. Huntley & Kretzmer Co., 419 Fourth Ave., New York, N. Y.
30. Herbert S. Swift, 1267 Commercial Trust Bldg., Philadelphia, Pa.
31. Insulating Concrete Corp., 3100 K. N. W., Washington, D. C.
32. H. L. McMurry Co., 25 Riverside Viaduct, Jacksonville, Fla.
33. C. T. Healy, P. O. Box 1106, Tampa, Fla.
34. W. R. Ousley, 2953 S. W. 32nd Ave., Miami, Fla.

*Z-Crete is the registered trademark of the Zonolite Company

ZONOLITE COMPANY

135 S. La Salle Street • Chicago 3, Illinois

OR MAIL THIS COUPON

Zonolite Company, Dept HV-98 135 S. La Salle St.
Chicago 3, Illinois
Please send me your free folder on Z-Crete*.

Name.....

Address.....

City.....State.....